TNV

M9961-02E070

YANMAR

SERVICE MANUAL

INDUSTRIAL DIESEL ENGINE

2TNV·3TNV series

(Indirect Injection System)

MODEL 2TNV70
3TNV70
3TNV76

YANMAR CO.,LTD.

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PREFACE

This manual describes the service procedures for the TNV series engines of indirect injection system that have been certified by the US EPA, California ARB and/or the 97/68/EC Directive for industrial use.

Please use this manual for accurate, quick and safe servicing of the said engine. Since the explanation in this manual assumes the standard type engine, the specifications and components may partially be different from the engine installed on individual work equipment (power generator, pump, compressor, etc.). Please also refer to the service manual for each work equipment for details.

The specifications and components may be subject to change for improvement of the engine quality without notice. If any modification of the contents described herein becomes necessary, it will be notified in the form of correction information each time.

California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

California Proposition 65 Warning

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.
Wash hands, after handling.

SAFETY LABELS

- Most accidents are caused by negligence of basic safety rules and precautions. For accident prevention, it is important to avoid such causes before development to accidents.
  Please read this manual carefully before starting repair or maintenance to fully understand safety precautions and appropriate inspection and maintenance procedures.
  Attempting at a repair or maintenance job without sufficient knowledge may cause an unexpected accident.

- It is impossible to cover every possible danger in repair or maintenance in the manual. Sufficient consideration for safety is required in addition to the matters marked ⚠ CAUTION. Especially for safety precautions in a repair or maintenance job not described in this manual, receive instructions from a knowledgeable leader.

- Safety marks used in this manual and their meanings are as follows:

⚠ DANGER **DANGER**-indicates an imminently hazardous situation which, if not avoided, WILL result in death or serious injury.

⚠ WARNING **WARNING**-indicates a potentially hazardous situation which, if not avoided, COULD result in death or serious injury.

⚠ CAUTION **CAUTION**-indicates a potentially hazardous situation which, if not avoided, MAY result in minor or moderate injury.

- **NOTICE**-indicates that if not observed, the product performance or quality may not be guaranteed.

Safety Precautions

(1) SERVICE AREA

⚠ WARNING

- Sufficient Ventilation

Inhalation of exhaust fumes and dust particles may be hazardous to ones health. Running engines welding, sanding, painting, and polishing tasks should be only done in well ventilated areas.

⚠ CAUTION

- Safe / Adequate Work Area

The service area should be clean, spacious, level and free from holes in the floor, to prevent “slip” or “trip and fall” type accidents.

⚠ CAUTION

- Bright, Safely Illuminated Area

The work area should be well lit or illuminated in a safe manner. For work in enclosed or dark areas, a “drop cord” should be utilized. The drop cord must have a wire cage to prevent bulb breakage and possible ignition of flammable substances.

⚠ CAUTION

- Safety Equipment

Fire extinguisher(s), first aid kit and eye wash / shower station should be close at hand (or easily accessible) in case of an emergency.

(2) WORK – WEAR (GARMENTS

⚠ CAUTION

● Safe Work Clothing

Appropriate safety wear (gloves, special shoes/boots, eye/ear protection, head gear, harness', clothing, etc.) should be used/worn to match the task at hand. Avoid wearing jewelry, unbuttoned cuffs, ties or loose fitting clothes around moving machinery. A serious accident may occur if caught in moving/rotating machinery.

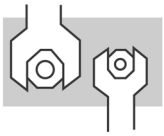
(3) TOOLS

⚠ WARNING

● Appropriate Lifting / Holding

When lifting an engine, use only a lifting device (crane, jack, etc.) with sufficient lifting capacity. Do not overload the device. Use only a chain, cable, or lifting strap as an attaching device. Do not use rope, serious injury may result.
To hold or support an engine, secure the engine to a support stand, test bed or test cart designed to carry the weight of the engine. Do not overload this device, serious injury may result.
Never run an engine without being properly secured to an engine support stand, test bed or test cart, serious injury may result.

⚠ CAUTION



● Appropriate Tools

Always use tools that are designed for the task at hand. Incorrect usage of tools may result in damage to the engine and or serious personal injury.

(4) GENUINE PARTS and MATERIALS

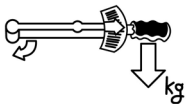
⚠ CAUTION

● Genuine Parts

Always use genuine YANMAR parts or YANMAR recommended parts and goods. Damage to the engine, shortened engine life and or personal injury may result.

(5) FASTENER TORQUE

⚠ WARNING



● Torqueing Fasteners

Always follow the torque values and procedures as designated in the service manual. Incorrect values, procedures and or tools may cause damage to the engine and or personal injury.

(6) Electrical

⚠ WARNING

● Short Circuits

Always disconnect the (-) Negative battery cable before working on the electrical system. An accidental “short circuit” may cause damage, fire and or personal injury. Remember to connect the (-) Negative battery cable (back onto the battery) last.
Fasten the terminals tightly.

⚠ WARNING

● Charging Batteries

Charging wet celled batteries produces hydrogen gas. Hydrogen gas is extremely explosive. Keep sparks, open flame and any other form of ignition away. Explosion may occur causing severe personal injury.

⚠ WARNING

● Battery Electrolyte

Batteries contain sulfuric acid. Do NOT allow it to come in contact with clothing, skin and or eyes, severe burns will result.

(7) WASTE MANAGEMENT

⚠ CAUTION

Observe the following instructions with regard to hazardous waste disposal. Negligence of these will have a serious impact on environmental pollution concerns.

1) Waste fluids such as lube oil, fuel and coolant shall be carefully put into separate sealed containers and disposed of properly.
2) Do NOT dispose of waste materials irresponsibly by dumping them into the sewer, overland or into natural waterways.
3) Waste materials such as oil, fuel, coolant, solvents, filter elements and batteries, must be disposed of properly according to local ordinances. Consult the local authorities or reclamation facility.

(8) FURTHER PRECAUTIONS

⚠ WARNING

● Fueling / Refueling

Keep sparks, open flames or any other form of ignition (match, cigarette, etc.) away when fueling/refueling the unit. *Fire and or an explosion may result.*

⚠ WARNING

● Hot Surfaces.

Do NOT touch the engine (or any of its components) during running or shortly after shutting it down. *Scalding / serious burns may result.* Allow the engine to cool down before attempting to approach the unit.

⚠ WARNING

● Rotating Parts

Be careful around moving/rotating parts. Loose clothing, jewelry, ties or tools may become entangled causing damage to the engine and or severe personal injury.

⚠ WARNING

● Preventing burns from scalding

1) Never open the radiator filler cap shortly after shutting the engine down.
   Steam and hot water will spurt out and seriously burn you. Allow the engine to cool down before attempt to open the filler cap.
2) Securely tighten the filler cap after checking the radiator.
   Steam can spurt out during engine running, if tightening loose.

Precautions for Service Work

(1) Precautions for Safety

Read the safety precautions given at the beginning of this manual carefully and always mind safety in work.

(2) Preparation for Service Work

Preparation is necessary for accurate, efficient service work. Check the customer ledger file for the history of the engine.

- Preceding service date
- Period/operation hours after preceding service
- Problems and actions in preceding service
- Replacement parts expected to be required for service
- Recording form/check sheet required for service

(3) Preparation before Disassembly

- Prepare general tools, special service tools, measuring instruments, oil, grease, nonreusable parts, and parts expected to be required for replacement.
- When disassembling complicated portions, put matchmarks and other marks at places not adversely affecting the function for easy reassembly.

(4) Precautions in Disassembly

- Each time a parts is removed, check the part installed state, deformation, damage, roughening, surface defect, etc.
- Arrange the removed parts orderly with clear distinction between those to be replaced and those to be used again.
- Parts to be used again shall be washed and cleaned sufficiently.
- Select especially clean locations and use clean tools for disassembly of hydraulic units such as the fuel injection pump.

(5) Precautions for Inspection and Measurement

Inspect and measure parts to be used again as required to determine whether they are reusable or not.

(6) Precautions for Reassembly

- Reassemble correct parts in correct order according to the specified standards (tightening torques, and adjustment standards). Apply oil important bolts and nuts before tightening when specified.
- Always use genuine parts for replacement.
- Always use new oil seals, O-rings, packings and cotter pins.
- Apply sealant to packings depending on the place where they are used. Apply of grease to sliding contact portions, and apply grease to oil seal lips.

(7) Precautions for Adjustment and Check

Use measuring instruments for adjustment to the specified service standards.

How to Read this Manual

(1) Range of Operation Explanation

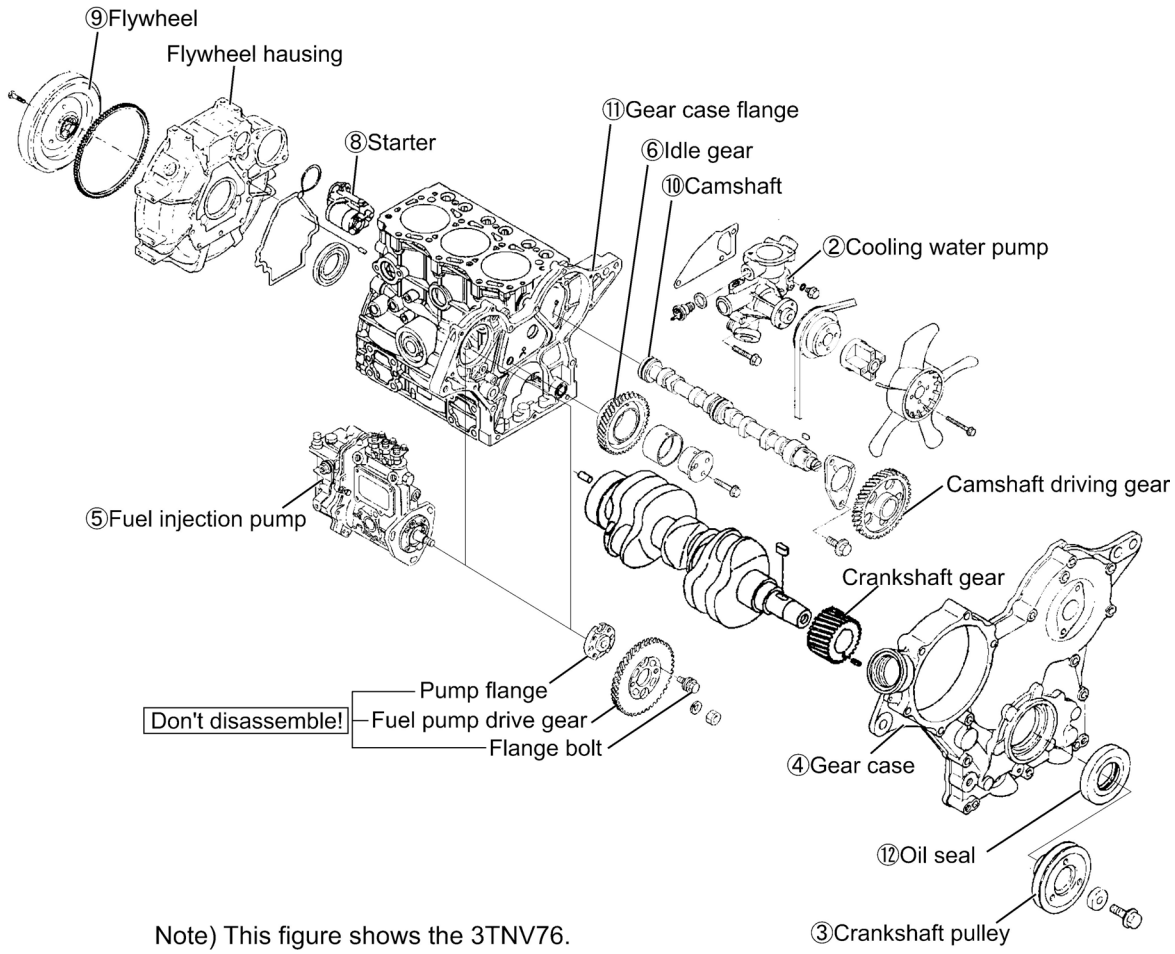
This manual explains the troubleshooting, installation/removal, replacement, disassemble/reassembly, inspection, adjustment and adjusting operation procedures for the TNV series engines with direct injection system.

Refer to the manufacturer’s manual for each of the fuel injection pump, governor, starting motor and alternator except for their installation.

(2) How to Read the Explanations

- An exploded view, sectional views, a system diagram, etc. are shown at the beginning of each section as required for easy understanding of the mounted states of the components.
- For the removal/installation of each part, the procedure is shown with the procedural step No. in the illustration.
- Precautions and key points for disassembly and reassembly of parts are described as **points**. In the explanation for each point, detailed operation method, information, standard and precautions are described.

Description Example



Note) This figure shows the 3TNV76.

- Disassembly procedure

1) Follow steps (1) to (15) of the cylinder head disassembly procedure.
2) Remove the cooling water pump.
3) Remove the crankshaft pulley. (**Point 1**) ← Operation point to be explained on a later page.

- Operation points

Disassemble: Service point for removal
Reassemble: Service point for installation
Disassemble-Reassemble: Service point required in both removal and installation.

- Contents omitted in this manual
  Though the following jobs are omitted in the explanation in this manual, they should be conducted in actual work:
  3) Jacking up and lifting
  4) Cleaning and washing of removed parts as required
  5) Visual inspection

(3) Definition of Terms

[NOTICE]: Instruction whose negligence is very likely to cause an accident. Always observe it.

Standard: Allowable range for inspection and adjustment.

Limit: The maximum or minimum value that must be satisfied during inspection or adjustment.

(4) Abbreviations

Abbreviation	Meaning	Abbreviation	Meaning
Assy	assembly	T.D.C.	top dead center
Sub-Assy	sub-assembly	B.D.C.	bottom dead center
a.T.D.C	after top dead center	OS	oversize
b.T.D.C	before top dead center	US	undersize
STD	Standard	Min^{-1}	revolutions per minute
IN	Intake	PS	Output (metric horsepower)
EX	Exhaust	T	Bolt/nut tightening torque

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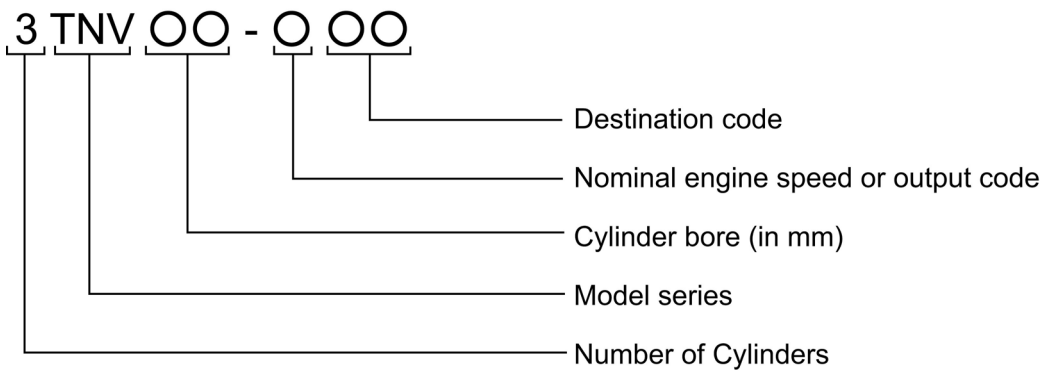
1. General

1.1 Engine Nomenclature



The engine specification class

Classification	Load	Engine speed	Available engine speed at nominal output (min^{-1})
CL	Constant load	Constant speed	1500/1800
CH	Constant load	Constant speed	3000/3600
VM	Variable load	Variable speed	2000～3000
VH	Variable load	Variable speed	3000～3600

※ The engine specification class (VM /CHor VH) is described in the specifications table.

1.2 Specifications

NOTE:

1) The information described in the engine specifications tables (the next page and after) is for "standard" engine. To obtain the information for the engine installed in each machine unit, refer to the manual provided by the equipment manufacturer.

2) Engine rating conditions are as follows (SAE J1349, ISO 3046/1)
- Atmospheric condition: Room temp. 25℃, Atmospheric press. 100 kPa (750mm Hg), Relative humidity 30%
- Fuel temp: 40℃ (Fuel injection pump inlet)
- With cooling fan, air cleaner, exhaust silencer (Yanmar standard parts)
- After running-in hours. Output allowable deviation: ±3%

(1) 2TNV70

Engine name		Unit	2TNV70										
Engine specification class		-	VM										
Type		-	Vertical, in-line, 4-cycle, water-cooled diesel engine										
Combustion chamber		-	Indirect injection										
Number of cylinders		-	2										
Cylinder bore×stroke		mm× mm	70×74										
Displacement		L	0.570										
Continuous rating	Revolving speed	min^{-1}	-										
	Output (NET)	kW (ps)	-										
Rated output	Revolving speed	min^{-1}	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
	Output (NET)	kW (ps)	6.0 (8.1)	6.3 (8.6)	6.8 (9.0)	7.0 (9.5)	7.3 (9.9)	7.6 (10.3)	7.9 (10.7)	8.2 (11.1)	8.5 (11.6)	8.8 (12.0)	9.1 (12.4)
Max. no-load speed (±25)		min^{-1}	2160	2250	2355	2460	2570	2675	2780	2890	2995	3100	3210
Ignition order		-	1-2-1(No.1 cylinder on flywheel side)										
Power take off		-	Flywheel										
Direction of rotation		-	Counterclockwise (viewed from flywheel)										
Cooling system		-	Radiator										
Lubrication system		-	Forced lubrication with trochoid pump										
Starting system		-	Electric										
Applicable fuel		-	Diesel oil, BS 2869 A1 or A2 (Cetane No.45 min.)										
Applicable lubricant		-	API grade class CD or CF										
Lubricant capacity (oil pan) *	Total	L	1.7										
	Effective	L	0.7										
Cooling water capacity (engine only)		L	0.6										
Engine Dimensions (with flywheel housing) * **	Overall length	mm	415										
	Overall width	mm	427										
	Overall height	mm	484										
Engine mass (dry) * ** (with flywheel housing)		kg	84										
Cooling fan (std.) *		mm	260 mm O/D, 5 blades pusher type F										
Crankshaft V pulley diameter* & Fun V pulley diameter (std.)		mm	ϕ110 & ϕ110										

* Items marked * may differ from the above depending on an engine installed on a machine unit.
** Engine mass and dimensions without radiator

(2) 3TNV70

Engine name		Unit	3TNV70							
Engine specification class		-	CH		VH					
Type		-	Vertical, in-line, 4-cycle, water-cooled diesel engine							
Combustion chamber		-	Indirect injection							
Number of cylinders		-	3							
Cylinder bore×stroke		mm× mm	70×74							
Displacement		L	0.854							
Continuous rating	Revolving speed	min^{-1}	3000	3600	-					
	Output (NET)	kW (ps)	12.1 (16.5)	14.5 (19.7)	-					
Rated output	Revolving speed	min^{-1}	3000	3600	3100	3200	3300	3400	3500	3600
	Output (NET)	kW (ps)	13.3 (18.1)	16.0 (21.7)	13.5 (18.4)	14.0 (19.0)	14.3 (19.4)	14.7 (20.0)	15.0 (20.4)	15.4 (21.0)
Max. no-load speed (±25)		min^{-1}	-	3800	3290	3400	3500	3600	3710	3815
Ignition order		-	1-3-2-1(No.1 cylinder on flywheel side)							
Power take off		-	Flywheel							
Direction of rotation		-	Counterclockwise (viewed from flywheel)							
Cooling system		-	Radiator							
Lubrication system		-	Forced lubrication with trochoid pump							
Starting system		-	Electric							
Applicable fuel		-	Diesel oil, BS 2869 A1 or A2 (Cetane No.45 min.)							
Applicable lubricant		-	API grade class CD							
Lubricant capacity (oil pan) *	Total	L	3.8		2.8					
	Effective	L	1.7		1.3					
Cooling water capacity (engine only)		L	0.9							
Engine Dimensions (with flywheel housing) * **	Overall length	mm	463							
	Overall width	mm	436							
	Overall height	mm	536		506					
Engine mass (dry) * ** (with flywheel housing)		kg	98							
Cooling fan (std.) *		mm	310 mm O/D, 5 blades pusher type F							
Crankshaft V pulley diameter* & Fun V pulley diameter (std.)		mm	ϕ110 & ϕ100							

* Items marked * may differ from the above depending on an engine installed on a machine unit.
** Engine mass and dimensions without radiator

3TNV70 (continue)

Engine name		Unit	3TNV70										
Engine specification class		-	VM										
Type		-	Vertical, in-line, 4-cycle, water-cooled diesel engine										
Combustion chamber		-	Indirect injection										
Number of cylinders		-	3										
Cylinder bore×stroke		mm×mm	70×74										
Displacement		L	0.854										
Continuous rating	Revolving speed	min^{-1}	-										
	Output (NET)	kW (ps)	-										
Rated output	Revolving speed	min^{-1}	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
	Output (NET)	kW (ps)	9.0 (12.2)	9.5 (12.9)	10.0 (13.5)	10.5 (14.3)	11.0 (14.9)	11.4 (15.5)	11.8 (16.1)	12.4 (16.8)	12.8 (17.4)	13.2 (18.0)	13.7 (18.6)
Max. no-load speed (±25)		min^{-1}	2160	2250	2355	2460	2570	2875	2780	2890	2995	3100	3210
Ignition order		-	1-3-2-1(No.1 cylinder on flywheel side)										
Power take off		-	Flywheel										
Direction of rotation		-	Counterclockwise (viewed from flywheel)										
Cooling system		-	Radiator										
Lubrication system		-	Forced lubrication with trochoid pump										
Starting system		-	Electric										
Applicable fuel		-	Diesel oil, BS 2869 A1 or A2 (Cetane No.45 min.)										
Applicable lubricant		-	API grade class CD										
Lubricant capacity (oil pan) *	Total	L	2.8										
	Effective	L	1.3										
Cooling water capacity (engine only)		L	0.9										
Engine Dimensions (with flywheel housing) * **	Overall length	mm	504										
	Overall width	mm	427										
	Overall height	mm	506										
Engine mass (dry) * ** (with flywheel housing)		kg	98										
Cooling fan (std.) *		mm	310 mm O/D, 5 blades pusher type F										
Crankshaft V pulley diameter* & Fun V pulley diameter (std.)		mm	ϕ110 & ϕ100										

* Items marked * may differ from the above depending on an engine installed on a machine unit.
** Engine mass and dimensions without radiator

(3) 3TNV76

Engine name		Unit	3TNV76							
Engine specification class		-	CH		VH					
Type		-	Vertical, in-line, 4-cycle water-cooled diesel engine							
Combustion chamber		-	Indirect injection							
Number of cylinders		-	3							
Cylinder bore×stroke		mm×mm	76×82							
Displacement		L	1.115							
Continuous rating	Revolving speed		3000	3600	-					
	Output (NET)	kW (ps)	15.1 (20.5)	17.7 (24.1)	-					
Rated output	Revolving speed	min^{-1}	3000	3600	3100	3200	3300	3400	3500	3600
	Output (NET)	kW (ps)	16.5 (22.5)	19.5 (26.5)	17.7 (24.0)	18.2 (24.8)	18.7 (25.4)	19.3 (26.2)	19.3 (26.3)	19.5 (26.5)
Max. no-load speed (±25)		min^{-1}	-	3800	3290	3400	3500	3600	3710	3815
Ignition order		-	1-3-2-1(No.1 cylinder on flywheel side)							
Power take off		-	Flywheel							
Direction of rotation		-	Counterclockwise (viewed from flywheel)							
Cooling system		-	Radiator							
Lubrication system		-	Forced lubrication with trochoid pump							
Starting system		-	Electric							
Applicable fuel		-	Diesel oil, BS 2869 A1 or A2 (cetane No.45 min.)							
Applicable lubricant		-	API grade class CD or CF							
Lubricant capacity (oil pan) *	Total	L	4.4		3.5					
	Effective	L	2.1		1.6					
Cooling water capacity (engine only)		L	0.9							
Engine Dimensions (with flywheel housing) * **	Overall length	mm	485							
	Overall width	mm	436							
	Overall height	mm	559		535					
Engine mass (dry) * ** (with flywheel housing)		kg	112							
Cooling fan (std.) *		mm	335 mm O/D, 5 blades pusher type F							
Crankshaft V pulley diameter* & Fun V pulley diameter (std.)		mm	ϕ110 & ϕ100							

* Items marked * may differ from the above depending on an engine installed on a machine unit.
** Engine mass and dimensions without radiator

3TNV76 (continue)

Engine name		Unit	3TNV76										
Engine specification class		-	VM										
Type		-	Vertical, in-line, 4-cycle water-cooled diesel engine										
Combustion chamber		-	Indirect injection										
Number of cylinders		-	3										
Cylinder bore×stroke		mm× mm	76×82										
Displacement		L	1.115										
Continuous rating	Revolving speed		-										
	Output (NET)	kW (ps)	-										
Rated output	Revolving speed	min^{-1}	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
	Output (NET)	kW (ps)	11.8 (16.1)	12.5 (17.0)	13.2 (17.9)	13.8 (18.7)	14.3 (19.5)	14.9 (20.3)	15.5 (21.1)	16.1 (21.9)	16.7 (22.7)	17.3 (23.5)	17.9 (24.3)
Max. no-load speed (±25)		min^{-1}	2160	2250	2355	2460	2570	2675	2780	2890	2995	3100	3210
Ignition order		-	1-3-2-1(No.1 cylinder on flywheel side)										
Power take off		-	Flywheel										
Direction of rotation		-	Counterclockwise (viewed from flywheel)										
Cooling system		-	Radiator										
Lubrication system		-	Forced lubrication with trochoid pump										
Starting system		-	Electric										
Applicable fuel		-	Diesel oil, BS 2869 A1 or A2 (cetane No.45 min.)										
Applicable lubricant		-	API grade class CD or CF										
Lubricant capacity (oil pan) *	Total	L	3.5										
	Effective	L	1.6										
Cooling water capacity (engine only)		L	0.9										
Engine Dimensions (with flywheel housing) * **	Overall length	mm	485										
	Overall width	mm	436										
	Overall height	mm	535										
Engine mass (dry) * ** (with flywheel housing)		kg	112										
Cooling fan (std.) *		mm	335 mm O/D, 6 blades pusher type F										
Crankshaft V pulley diameter* & Fun V pulley diameter (std.)		mm	ϕ110 & ϕ100										

* Items marked * may differ from the above depending on an engine installed on a machine unit.
** Engine mass and dimensions without radiator

1.3 Fuel Oil, Lubricating Oil and Cooling water

1.3.1 Fuel oil

IMPORTANT:
Only use the recommended fuel to obtain the best engine performance and prevent damage of parts, also prevent air pollution.

(1) Selection of fuel oil

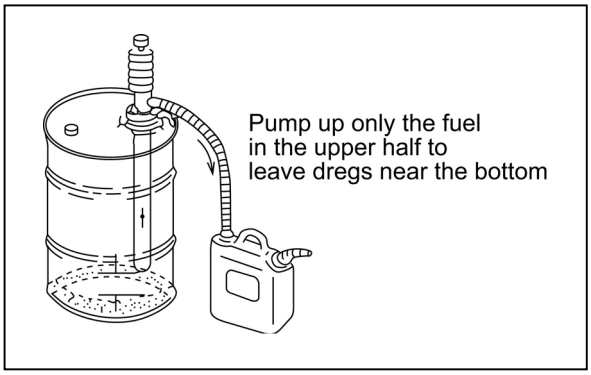
Use the following diesel fuels for best engine performance:
BS 2869 A1 or A2

Fuels equivalent to Japanese Industrial Standard, JIS. No. K2204-2

Fuel cetane number should be 45 or greater

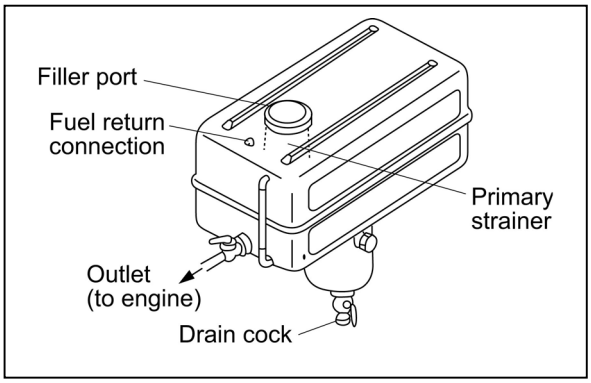
(2) Fuel handling

- Water and dust in the fuel oil can cause operation failure. Use containers which are clean inside to store fuel oil. Store the containers away from rain water and dust.
- Before supplying fuel, let the fuel container rest for several hours so that water and dust in the fuel are deposited on the bottom. Pump up only the clean fuel.



(3) Fuel tank

Be sure to attach a drain cock, precipitation trap and primary strainer to the fuel tank as shown illustration right.



1.3.2 Lubricating oil

IMPORTANT:
Use of other than the specified lube oil may cause inner parts seizure or early wear, leading to shorten the engine service life.

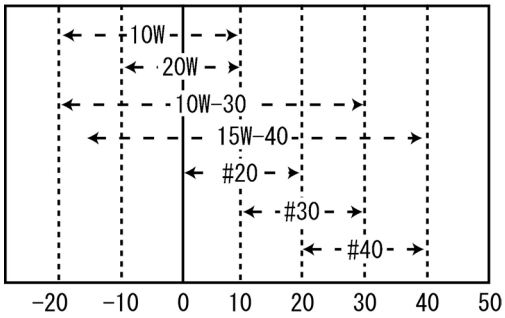
(1) Selection of lube oil

Use the following lube oil

- API classification ····· CD or CF
  (Standards of America Petroleum Institute)
- SAE viscosity ····· 10W-30 or 15W-40
  (Standard of Society of Automotive Engineering)

Lube oil with 10W30 or 15W40 can be used throughout the year.
(Refer to the right figure.)

Selection of viscosity
(SAE Service grade)



Atmospheric temperature (˚C)

15W-40/10W-30 can be used almost throughout the year.

(2) Handling of lube oil

- Carefully store and handle the oil so as to prevent dust or dirt entrance. When supplying the oil, pay attention and clean around the filler port.
- Do not mix different types of oil as it may adversely affect the lubricating performance.

⚠ CAUTION

When touching lube oil by hand, the skin of the hand may become rough. Be careful not to touch oil with your hands without protective gloves. If touch, wash your hands with soap and water thoroughly.

1.3.3 Cooling water

Use clean soft water and be sure to add the Long Life Coolant Antifreeze (LLC) in order to prevent rust built up and freezing. If there is any doubt over the water quality, distilled water or pre-mixed coolant should be used.
The coolants / antifreezes, which are good performance for example, are shown below.

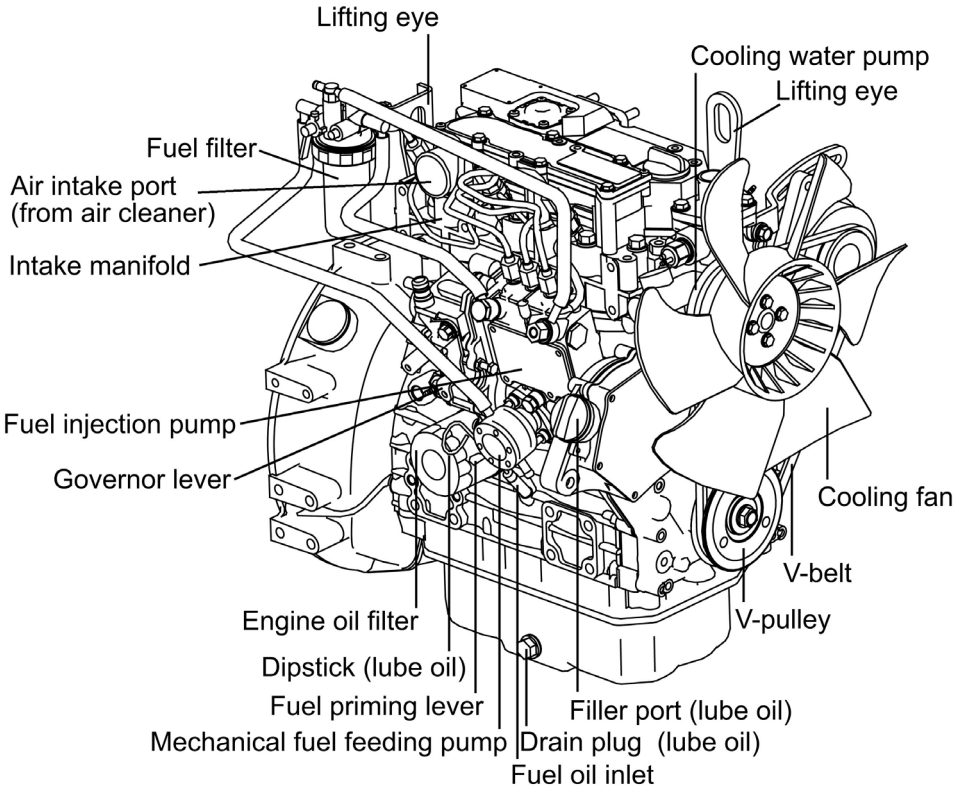
- TEXACO LONG LIFE COOLANT ANTIFREEZE, both standard and pre-mixed.
  Product codes 7997 and 7998
- HAVOLINE EXTENDED LIFE ANTIFREEZE / COOLANT
  Product code 7994

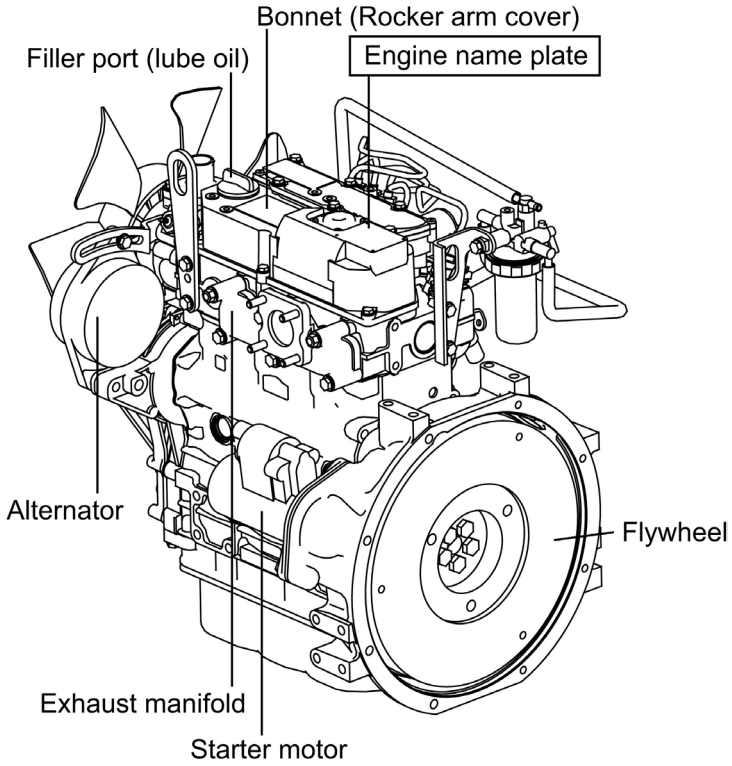
IMPORTANT:
- Be sure to add Long Life Coolant Antifreeze(LLC) to soft water. In cold season, the LLC is especially important. Without LLC, cooling performance will decrease due to scale and rust in the cooling water line. Without LLC, cooling water will freeze and expand to break the cooling line.
- Be sure to use the mixing ratios specified by the LLC manufacturer for your temperature range.
- Do not mix different types (brand) of LLC, chemical reactions may make the LLC useless and engine trouble could result.
- Replace the cooling water every once a year.

⚠ CAUTION

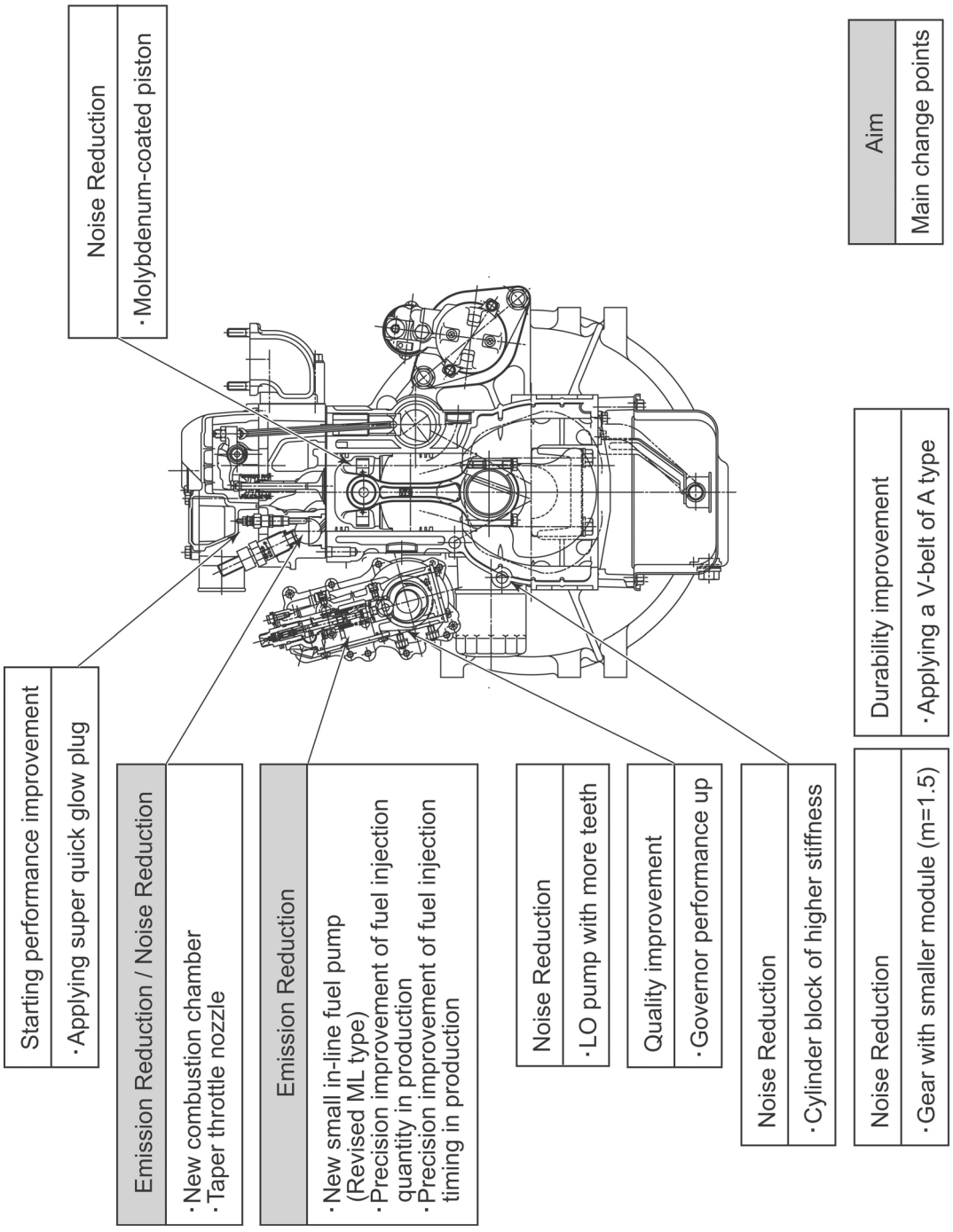
When handling Long Life Coolant Antifreeze, wear protective rubber gloves not to touch it. If LLC gets eyes or skin, wash with clean water at once.

1.4 Engine External Views





1.5 Structural Description



1.6 Exhaust gas emission regulation

The engines in this manual have been certified by the US EPA and/or California.

California
Proposition 65 Warning
Diesel engine exhaust and some of its constitutions are known to the State of California to cause cancer, birth defects, and other reproductive harm.

California
Proposition 65 Warning
Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. Wash hands after handling.

1.6.1 The Emission Standard in USA

(1) EPA Nonroad Diesel Engine Emission Standards

g/kW·hr(g/bhp·hr)

Engine Power	Tier	Model Year	NOx	HC	NMHC + NOx	CO	PM
kW < 8 (hp < 11)	Tier 1	2000	-	-	10.5 (7.8)	8.0 (6.0)	1.0 (0.75)
	Tier 2	2005	-	-	7.5 (5.6)	8.0 (6.0)	0.80 (0.60)
8 <= kW < 19 (11 <= hp < 25)	Tier 1	2000	-	-	9.5 (7.1)	6.6 (4.9)	0.80 (0.60)
	Tier 2	2005	-	-	7.5 (5.6)	6.6 (4.9)	0.80 (0.60)

Note1) The EPA emission regulation under 19kW is mentioned above.
Note2) As for Model year, the year which a regulation is applicable to is shown.

Engine classification	Transient smoke standards % opacity (acceleration/lug/peak modes)
Constant speed engine	Not regulated
Variable speed engine	20/15/50 or less

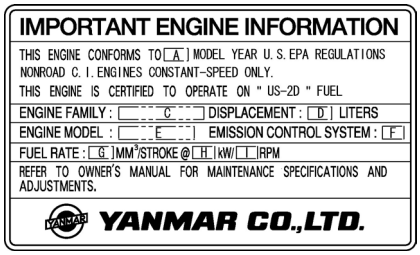
(2) California ARB Emission Regulation

The ARB emission standard is based on that of the EPA.

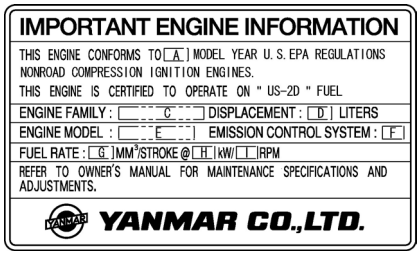
1.6.2 Engine identification

To identify the engines, the following emission control labels are affixed on the engines.

(1) Emission control labels of US EPA

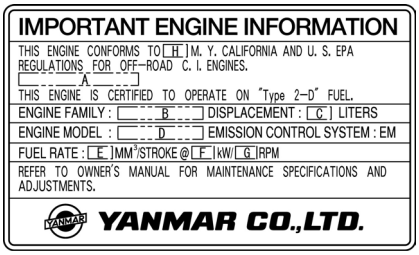

IMPORTANT ENGINE INFORMATION
THIS ENGINE CONFORMS TO [A] MODEL YEAR U. S. EPA REGULATIONS NONROAD C. I. ENGINES CONSTANT-SPEED ONLY.
THIS ENGINE IS CERTIFIED TO OPERATE ON " US-2D " FUEL
ENGINE FAMILY : [C] DISPLACEMENT : [D] LITERS
ENGINE MODEL : [E] EMISSION CONTROL SYSTEM : [F]
FUEL RATE : [G] MM3/STROKE @ [H] kW/[I] RPM
REFER TO OWNER'S MANUAL FOR MAINTENANCE SPECIFICATIONS AND ADJUSTMENTS.
YANMAR CO.,LTD.

EPA label for constant speed engines


IMPORTANT ENGINE INFORMATION
THIS ENGINE CONFORMS TO [A] MODEL YEAR U. S. EPA REGULATIONS NONROAD COMPRESSION IGNITION ENGINES.
THIS ENGINE IS CERTIFIED TO OPERATE ON " US-2D " FUEL
ENGINE FAMILY : [C] DISPLACEMENT : [D] LITERS
ENGINE MODEL : [E] EMISSION CONTROL SYSTEM : [F]
FUEL RATE : [G] MM3/STROKE @ [H] kW/[I] RPM
REFER TO OWNER'S MANUAL FOR MAINTENANCE SPECIFICATIONS AND ADJUSTMENTS.
YANMAR CO.,LTD.

EPA label for variable speed engines

(2) Emission control label for both EPA and ARB


IMPORTANT ENGINE INFORMATION
THIS ENGINE CONFORMS TO [H] M. Y. CALIFORNIA AND U. S. EPA REGULATIONS FOR OFF-ROAD C. I. ENGINES.
[A]
THIS ENGINE IS CERTIFIED TO OPERATE ON "Type 2-D" FUEL.
ENGINE FAMILY : [B] DISPLACEMENT : [C] LITERS
ENGINE MODEL : [D] EMISSION CONTROL SYSTEM : EM
FUEL RATE : [E] MM3/STROKE @ [F] kW/[G] RPM
REFER TO OWNER'S MANUAL FOR MAINTENANCE SPECIFICATIONS AND ADJUSTMENTS.
YANMAR CO.,LTD.

1.6.3 Guarantee Conditions for the EPA Emission Standard

The following guarantee conditions are set down in the operation manual. In addition to making sure that these conditions are met, check for any deterioration that may occur before the required periodic maintenance times.

(1) Requirement on engine operation condition

(a) Intake air depression

kPa(mmAq)

Initial	Permissible
≦ 2.94 (300)	≦ 6.23 (635)

(b) Exhaust gas back pressure

kPa(mmAq)

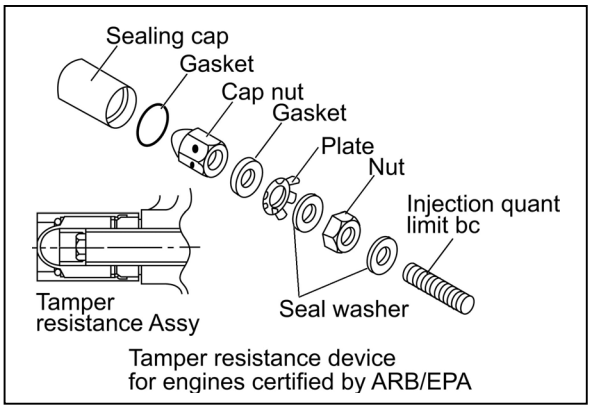
Initial	Permissible
≦ 12.75 (1300)	≦ 15.30 (1560)

(2) Fuel oil

The diesel fuel oil US No.2 diesel fuel oil.

(3) Tamper resistance

Do not remove the seals restricting injection quantity and engine speed.



Tamper resistance device for engines certified by ARB/EPA

(4) Perform maintenance without fail.

Note: Inspections to be carried out by the user and by the maker are divided and set down in the “List of Periodic Inspections” and should be checked carefully.

(5) Maintenance period and Quality guarantee period for exhaust emission related parts

The maintenance of the parts related to the exhaust emission must be carried out in the maintenance period as shown in the below table.

A guarantee period is that either the operation hours or years shown in the table come first in the condition that the maintenance inspection was carried out based on the “List of Periodic Maintenance Schedule”.

	Maintenance period		Quality Guarantee Period
Parts / Power Rating	Fuel nozzle cleaning	Adjustment, cleaning, repairs for fuel nozzle, fuel pump, turbocharger, electronic control unit etc.	For nozzle, fuel pump, turbocharger
kW < 19 And constant speed engines beyond 3000min^{-1} under 37kW	Every 1500 hours	Every 3000 hours	1500 hours / 2 years

2. Inspection and Adjustment

2.1 Periodic Maintenance Schedule

The engine periodic inspection timing is hard to determine as it varies with the application, load status, qualities of the fuel and lube oils used and handling status. General rules are described here.

○:User-maintenance ◎:Parts replacement ●:Shop-inspection

Classification	Item	Daily	Maintenance period				
			Every 50 hours	Every 250 hours or 3 months	Every 500 hours or 6 months	Every 1000 hours or one year	Every 2000 hours or two years
Whole	Visual check around engine	○					
Fuel oil system	Fuel tank level check and fuel supply	○					
	Fuel tank draining		○				
	Bleeding the fuel system		○				
	Water separator draining		○				
	Water separator cleaning				○		
	Fuel filter element replacement				◎		
Lubricating oil system	Lube oil level check and replenishment	○					
	Lube oil replacement		◎ 1st time	◎ 2nd time and thereafter			
	Lube oil filter replacement						
Cooling water system	Cooling water level check and replenishment	○					
	Radiator fin cleaning			○			
	Cooling fan V-belt tension check		○ 1st time	○ 2nd time and thereafter			
	Cooling water replacement					◎	
	Cooling water path flushing and maintenance						●
Rubber house	Fuel pipe and cooling water pipe inspection and maintenance	○					●
Governor	Inspection and adjustment of governor lever and accelerator	○		○			
Air intake system	Air cleaner cleaning and element replacement			○	◎		
	Diaphragm assy inspection					● (2 years)	
Electrical system	Warning lamp & instruments function check	○					
	Battery electrolyte level check and battery recharging		○				
Cylinder head	Intake/exhaust valve clearance adjustment					●	
	Intake/exhaust valve seat lapping						●
Fuel injection pump and nozzle	Fuel injection nozzle pressure inspection					●*	
	Fuel injection timing adjustment Fuel pump inspection and adjustment						●*

*) EPA allows to maintain the emission related parts as shown in 1.6.3 of chapter1.

2.2 Periodic Inspection and Maintenance Procedure

2.2.1 Check before Daily Operation

Be sure to check the following points before starting an engine every day.

No.	Inspection Item
(1)	Visual check around engine
(2)	Fuel tank level check and fuel supply
(3)	Lube oil level check and replenishment
(4)	Cooling water level check and replenishment
(5)	Fuel pipe and cooling water pipe inspection and maintenance
(6)	Inspection and adjustment of governor lever and accelerator
(7)	Warning lamp & instruments function check

(1) Visual check around engine.

If any problem is found, do not use before the engine repairs have been completed.

- Oil leak from the lubrication system
- Fuel leak from the fuel system
- Cooling water leak from the cooling water system
- Damaged parts
- Loosened or lost bolts
- Fuel, radiator rubber hoses, V belt cracked, loosened clamp

(2) Fuel tank level check and fuel supply

Check the remaining fuel oil level in the fuel tank and refuel the recommended fuel if necessary. (Refer to 1.3.1

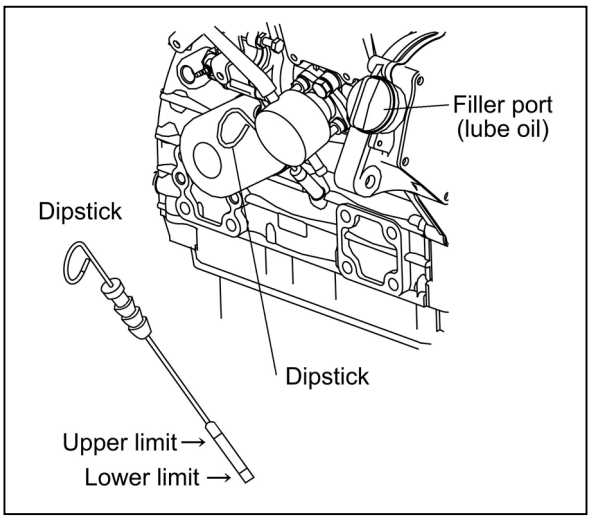
(3) Lube oil level check and replenishment

(a) Checking oil level

Check the lube oil level with the dipstick, after adjusting the posture of the machine unit so that an engine may become a horizontality. Insert the dipstick fully and check the oil level. The oil shall not be contaminated heavily and have appropriate viscosity. No Cooling water or diesel fuel shall be mixed. When lube oil is supplied after the engine running, check the lube oil level after about 10 minutes pass after the engine shutdown so that the lube oil inside may be returned to the oil pan.

Standard

The level shall be between the upper and lower limit lines on the dipstick.



(Unit: liter)

Model	Class	Total volume	Effective volume
2TNV70	VM	1.7	0.7
3TNV70	VM/VH	2.8	1.3
	CH	3.8	1.7
3TNV76	VM/VH	3.5	1.6
	CH	4.4	2.1

Lube oil capacity may differ from the above volume depending on an engine installed on a machine unit.

(b) Replenishing oil pan with lube oil

If the remaining lube oil level is low, fill the oil pan with the specified lube oil to the specified level through the filler port.

[NOTICE]

The oil should not be overfilled to exceed the upper limit line. Otherwise a naturally-aspirated engine may intake lube oil in the combustion chamber during the operation, then white smoke, oil hummer or urgent rotation may occur, because the blowby gas is reduced in the suction air flow.
In case of turbo-charged engine oil may jet out from the breather or the engine may become faulty.

(4) Cooling water level check and replenishment

Daily inspection of cooling water should be done only by coolant recovery tank.

⚠ WARNING

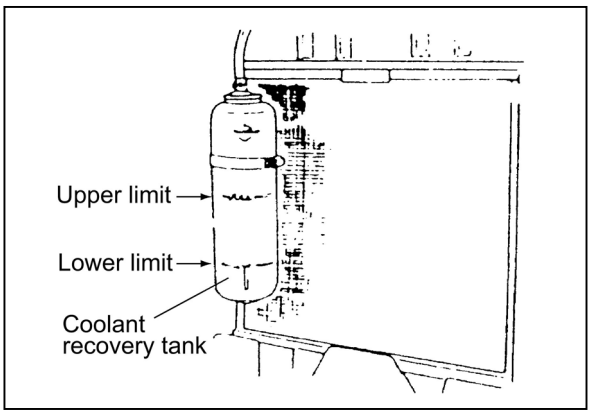
- Never open the radiator filler cap while the engine and radiator are still hot. Steam and hot water will spurt out and seriously burn you. Wait until the radiator is cooled down after the engine has stopped, wrap the filler cap with a rag piece and turn the cap slowly to gently release the pressure inside the radiator.
- Securely tighten the filler cap after checking the radiator. Steam can spurt out during operation, if the cap is tightened loosely.

(a) Checking cooling water volume

Check the cooling water level in the coolant recovery tank. If the water level is close to the LOW mark, open the coolant recovery tank cap and replenish the coolant recovery tank with clean soft water to the FULL mark.

Standard

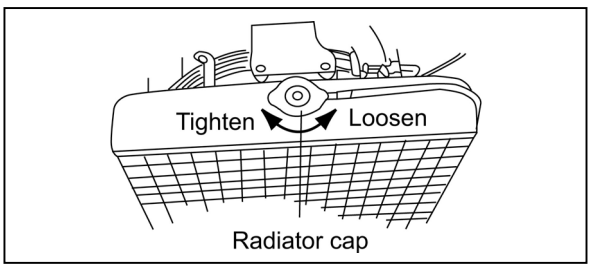
The water level of the coolant recovery tank shall be between the upper and lower limit lines.



(b) Replenishing engine with water

If the coolant recovery tank water level is lower than the LOW mark, open the radiator cap and check the cooling water level in the radiator. Replenish the radiator with the cooling water, if the level is low.

- Check the cooling water level while the engine is cool.
  Checking when the engine is hot is dangerous. And the water volume is expanded due to the heat.
- Daily cooling water level check and replenishing shall be done only at the coolant recovery tank. Usually do not open the radiator cap to check or replenish.



IMPORTANT:

If the cooling water runs short quickly or when the radiator runs short of water with the coolant recovery tank level unchanged, water may be leaking or the air tightness may be lost. Increase in the coolant recovery tank water level during operation is not abnormal.

The increased water in the coolant recovery tank returns to the radiator when the engine is cooled down.

If the water level is normal in the coolant recovery tank but low in the radiator, check loosened clamping of the rubber hose between the radiator and coolant recovery tank or tear in the hose.

Standard

Engine: The radiator shall be filled up.

(Unit: liter)

Model	Cooing water volume in an engine
2TNV70	0.6
3TNV70 3TNV76	0.9

Engine cooling water capacity may differ from the above volume depending on an engine installed on a machine unit.

(5) Fuel pipe and cooling water pipe inspection and maintenance

Check the rubber hoses for fuel and cooling water pipes cracked. If the cracked hose is found, replace it with new one.

Check the loosened clamp. If found, tighten it.

(6) Inspection and adjustment of governor lever and accelerator

Make sure the accelerator of the machine unit can be operated smoothly before starting the engine. If it feels heavy to manipulate, lubricate the accelerator cable joints and pivots. Adjust the accelerator cable if there is a dislocation or excessive play between the accelerator and the governor lever. Refer to 3.2.3..

(7) Warning lamp & instruments function check

Before and after starting the engine, check to see that the alarm function normally. Failure of alarm cannot warn the lack of the lube oil or the cooling water. Make it a rule to check the alarm operation before and after starting engine every day. Refer to each manual for machine units in details.

2.2.2 inspection after initial 50 hours operation

Be sure to check the following points after initial 50 hours operation, thereafter every 250 hours or 3 months operation.

No.	Inspection Item
(1)	Lube oil and filter replacement
(2)	V-belt tension check

(1) Lube oil and filter replacement

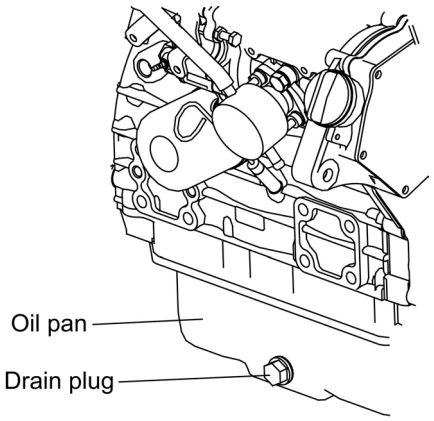
⚠ CAUTION

When an engine is still hot, be careful with a splash of lube oil which may cause burns. Replace lube oil after the lube oil becomes warm. It is most effective to drain the lube oil while the engine is still warm.

In early period of use, the lube oil gets dirty rapidly because of the initial wear of internal parts. Replace the lube oil earlier.
Lube oil filter should also be replaced when the lube oil is replaced.
The procedure of lube oil and lube oil filter replacement is as follows.

(a) Drain lube oil

- Remove the oil filler cap to drain easily while drainig the lube oil.
- Remove the oil filler cap to drain easily while drainig the lube oil.
- Loosen the drain plug using a wrench (customer procured) to drain the lube oil.
- Securely tighten the drain plug after draining the lube oil.



The location depends on the engine installed on the machine unit

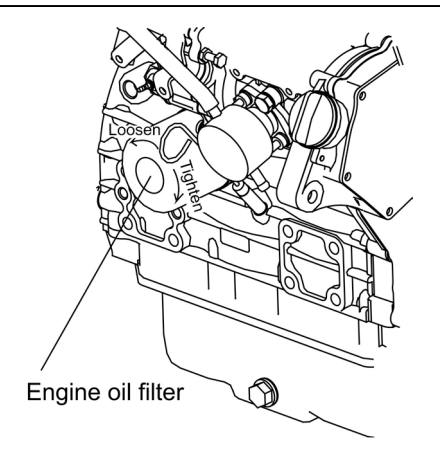
[NOTICE]
Use a socket wrench or a closed wrench when removing or tightening a drain plug.
Don't use a spanner because it has the possibility that the spanner will slip and it will get hurt.

(b) Replacing oil filter

- Turn the lube oil filter counter-clockwise using a filter wrench (customer procured) to remove it.
- Clean the mounting face of the oil filter.
- Moisten the new oil filter gasket with the lube oil and install the new lube oil filter manually turning it clockwise until it comes into contact with the mounting surface, and tighten it further to 3/4 of a turn with the filter wrench.

  Tightening torque: 20∼24N·m (2.0∼2.4kgf·m)

Applicable oil filter Part No.
119305-35150



(c) Filling oil and inspection

- Fill with new lube oil until it reaches the specified level.

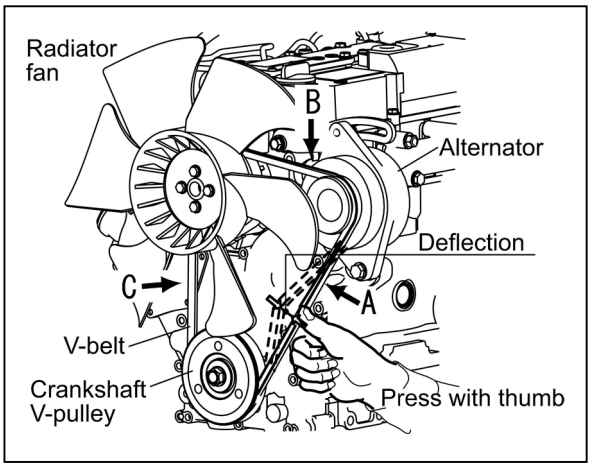
IMPORTANT:

Do not overfill the oil pan with lube oil.
Be sure to keep the specified level between upper and lower limit on the dipstick.

- Warm up the engine by running for 5 minutes while checking any oil leakage
- Stop the engine after warming up and leave it stopping for about 10 minute to recheck the lube oil level with dipstick and replenish the lube oil. If any oil is spilled, wipe it away with a clean cloth.

(2) V-belt tension check

When there is not enough tension in the V-belt, the V-belt will slip making it impossible for the alternator to generate power and cooling water pump and cooling fan will not work causing the engine to overheat. Check and adjust the V-belt tension (deflection) in the following manner.



[NOTICE]

Be especially careful not to splash lube oil on the V-belt, because it will cause slipping, stretching and aging of the belt.

1) Press the V-belt with your thumb [approx. 98N(10kgf)] at the middle of the V-belt span to check the tension (deflection).
Available positions to check and adjust the V-belt tension (deflection) are at the A, B or C direction as shown in the illustration right.
You may choose a position whichever you can easily carry out the check and adjustment on the machine unit.

- "New V-belt" refers to a V-belt which has been used less than 5 minutes on a running engine.
- "Used V-belt" refers to a V-belt, which has been used on a running engine for 5 minutes or more.

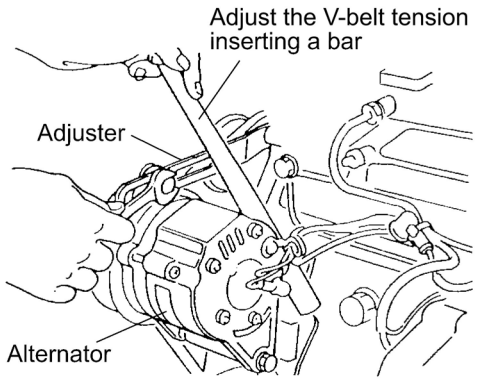
The specified deflection to be measured at each position should be as follows.

(Unit: mm)

Direction	A	B	C
For used V-belt	10~14	7~10	9~13
For new V-belt	8~12	5~8	7~11

2) If necessary, adjust the V-belt tension (deflection).a To adjust the V-belt tension, loosen the set bolt and move the alternator to tighten the V-belt.

3) After replacing with a new V-belt and adjusting it, run the engine for 5 minutes and readjust the deflection to the value in the table above.



Tension adjustment

4) Visually check the V-belt for cracks, oiliness or wear. If any, replace the V-belt with new one.

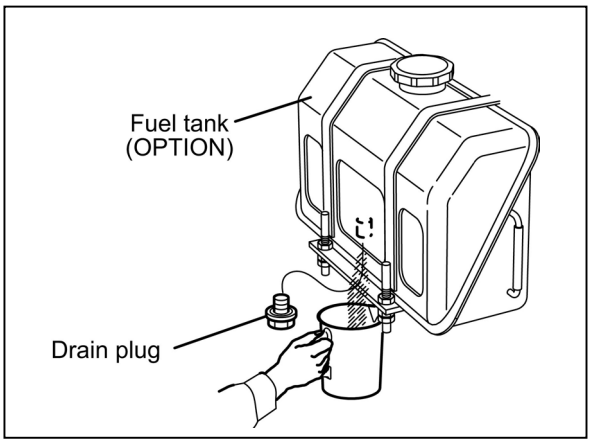
2.2.3 Inspection every 50 hours

Be sure to check the following points every 50 hours operation.

No.	Inspection Item
(1)	Fuel tank draining
(2)	Water separator draining
(3)	Bleeding the fuel system
(4)	Battery electrolyte level check and battery recharging

(1) Fuel tank draining

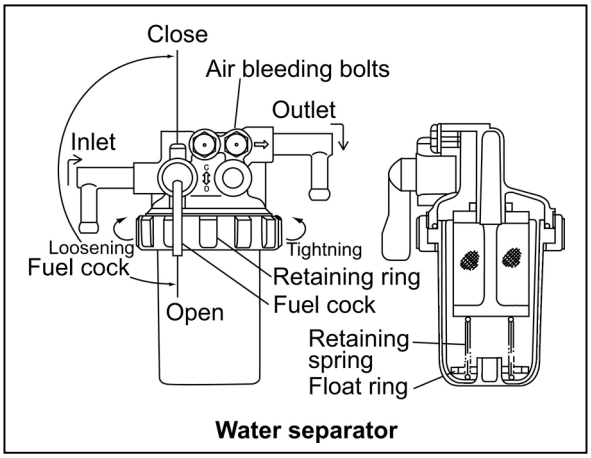
1) Prepare a waste oil container.
2) Remove the drain plug of the fuel tank to drain (water, dust, etc.) from the fuel tank bottom.
3) Drain until fuel with no water and dust flow out. Then tighten the drain plug firmly.



(2) Water separator draining

Drain off the water separator whenever there is a lot of drain collected in the water separator at the bottom of the cup even if not the time for periodic inspection hour. The cup of the water separator is made from semi-transparency material and in the cup, the red colored float ring which rises on the surface of the drain is installed to visualize the amount of drain. Drain off the water separator in the following manner.

1) Close the fuel cock.
2) Loosen the retainer ring, and remove the cup, then throw collected water and trash away.
3) Put a float ring and a spring in the cup, and tighten the retainer ring.
   Tightening torque: 13-16Nm (1.3-1.6kgf-m)
4) Be sure to bleed air in the fuel system.



Water separator

(3) Bleeding the fuel system

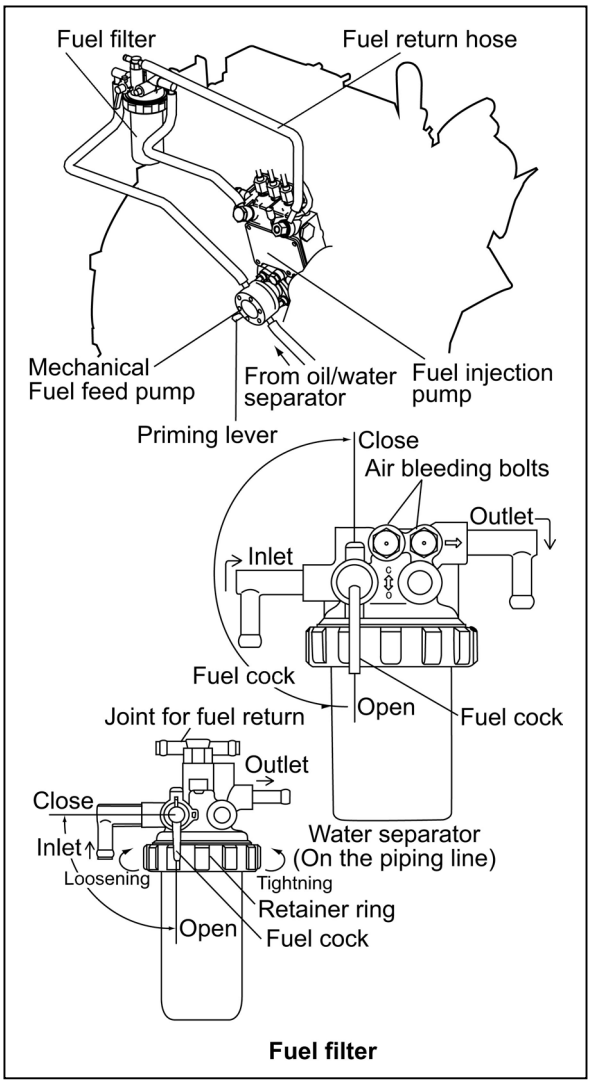
Bleed the fuel system according to the following procedures. When there is air in the fuel system, the fuel injection pump will not be able to function.

1) Check the fuel oil level in the fuel tank. Refuel if insufficient.
2) Open the fuel cocks of the water separator and the fuel filter.
3) Loosen the air bleeding bolt on the water separator by turning 2~3 turns to the counter-clockwise by using a screw driver.
4) When the fuel coming out is clear and not mixed with any bubble, tighten the air bleeding bolt.
5) Feed the fuel with the fuel priming pump or electro-magnetic fuel feed pump.

   In case of an engine installed with a fuel priming pump.
   Move the priming lever by hand up and down, and feed fuel until the fuel surface inside the fuel filter cup goes up and the air disappears inside. (Move the lever until feeling your hand slightly heavy.)

   In case of an engine using the electro-magnetic fuel feed pump.
   Turn the starter switch to the ON position, and hold it in the position and operate the electro-magnetic fuel feed pump for 10~15 seconds to bleed the fuel system automatically.

   Note:
   Don't do air bleeding by a starting motor.



Fuel filter

(4) Battery electrolyte level check and battery recharging

⚠ WARNING

Fire due to electric short-circuit

- Make sure to turn off the battery switch or disconnect the negative cable (-) before inspecting the electrical system. Failure to do so could cause short-circuiting and fires.
- Always disconnect the (-) Negative battery cable first before disconnecting the battery cables from battery. An accidental "Short circuit" may cause damage, fire and or personal injury.
  And remember to connect the (-) Negative battery cable (back onto the battery) last.

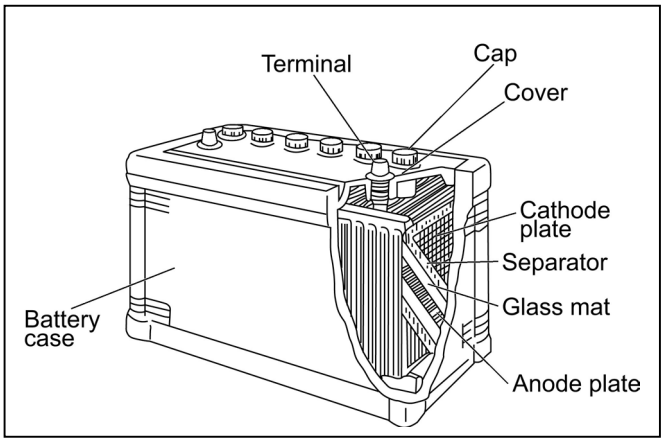
Proper ventilation of the battery area

Keep the area around the battery well ventilated, paying attention to keep away any fire source. During operation or charging, hydrogen gas is generated from the battery and can be easily ignited.

Do not come in contact with battery electrolyte

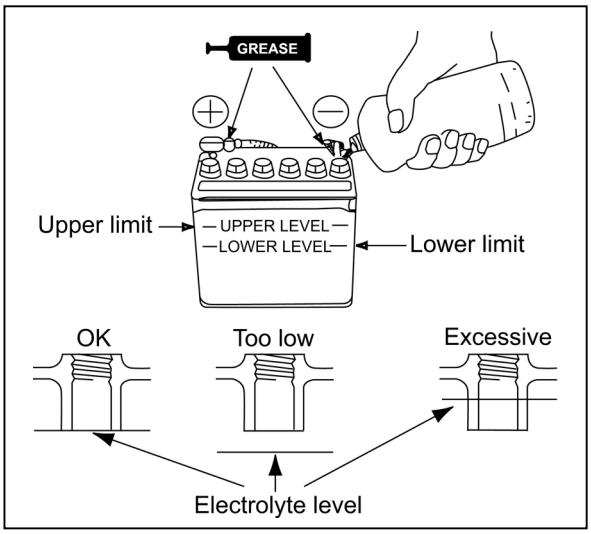
Pay sufficient attention to avoid your eyes or skin from being in contact with the fluid. The battery electrolyte is dilute sulfuric acid and causes burns. Wash it off immediately with a large amount of fresh water if you get any on you.

Battery structure



(1) Electrolyte level

- Check the level of fluid in the battery.
  When the amount of fluid nears the lower limit, fill with battery fluid (available in the market) to the upper limit. If operation continues with insufficient battery fluid, the battery life is shortened, and the battery may overheat and explode.
- Battery fluid tends to evaporate more quickly in the summer, and the fluid level should be checked earlier than the specified times.
- If the engine cranking speed is so slow that the engine does not start up, recharge the battery.
- If the engine still will not start after charging, replace the battery.
- Remove the battery from the battery mounting of the machine unit after daily use if letting the machine unit leave in the place that the ambient temperature could drop at -15℃ or less. And store the battery in a warm place until the next use the unit to start the engine easily at low ambient temperature.



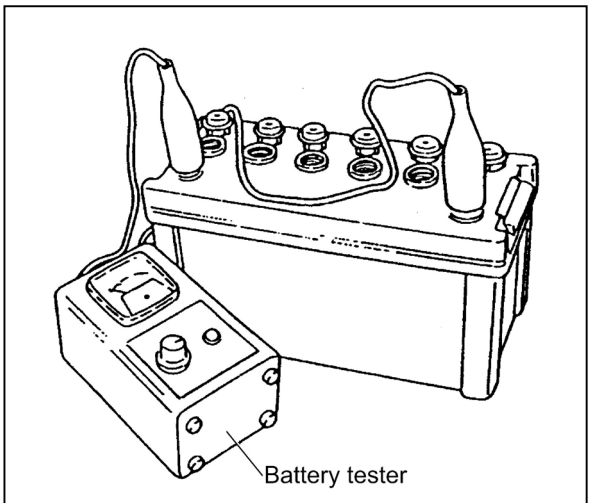
(2) Battery charge

Use a battery tester or hydrometer and check the battery condition. If the battery is discharged, recharge it.

(a) Measurement with a battery tester

When checking the battery with the batter tester, connect the red clip of the tester to the battery positive (+) terminal and black clip to the battery negative (-) terminal by pinching them securely, and judge the battery charge level from the indicator position.

Green zone: Normal
Yellow zone: Slightly discharged
Red zone: Defective or much discharged

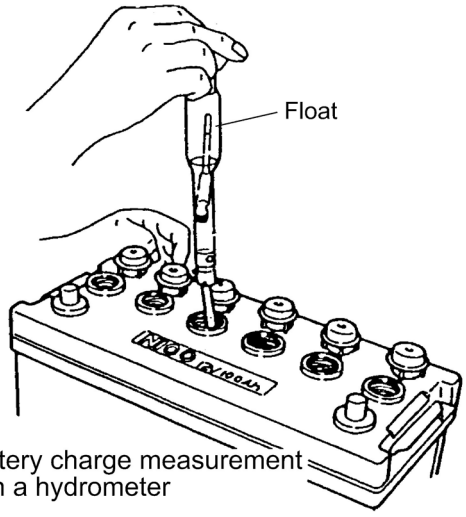


Battery charge measurement with battery tester

(b) Measurement with hydrometer
When using a hydrometer, the measured specific gravity must be corrected according to the temperature at the time of measurement. The specific gravity of battery electrolyte is defined with 20℃ as the standard. Since the specific gravity increases or decreases by 0.0007 when the temperature varies by 1℃, correct the value according to the equation below.

$S_{20} = St + 0.007 (t - 20)$

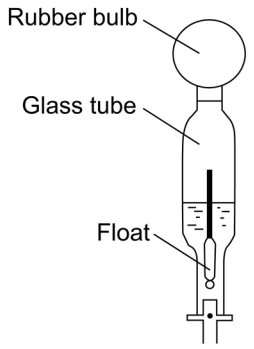
- S_{20}: Specific gravity co to 20℃
- St: Measured specific
- t: Measured electrol temperature



Battery charge measurement with a hydrometer

Specific gravity and remaining battery charge

Specific gravity (20℃)	Discharged quantity of electricity (%)	Remaining charge (%)
1.28	0	100
1.26	10	90
1.24	20	80
1.23	25	75

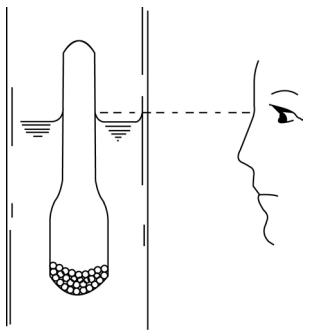


Hydrometer structure

(3) Terminals
Clean if corroded or soiled.

(4) Mounting bracket
Repair or replace it if corroded.
Retighten if loosened.

(5) Battery appearance
Replace the battery if cracked or deformed.
Clean with fresh water if contaminated.


How to read hydrometer

2.2.4 Inspection every 250 hours or 3 months

Be sure to check the following points every 250 hours or 3 months operation, whichever comes first.

No.	Inspection Item
(1)	Lube oil and filter replacement
(2)	Radiator fin cleaning
(3)	V-belt tension check
(4)	Inspection and adjustment of governor lever and accelerator
(5)	Air cleaner cleaning and element replacement

(1) Lube oil and filter replacement (The second replacement and after)

Replace the lube oil every 250 hours operation from 2nd time and on. Replace the lube oil filter at the same time. Refer to 2.2.2.(1).

(2) Radiator fin cleaning

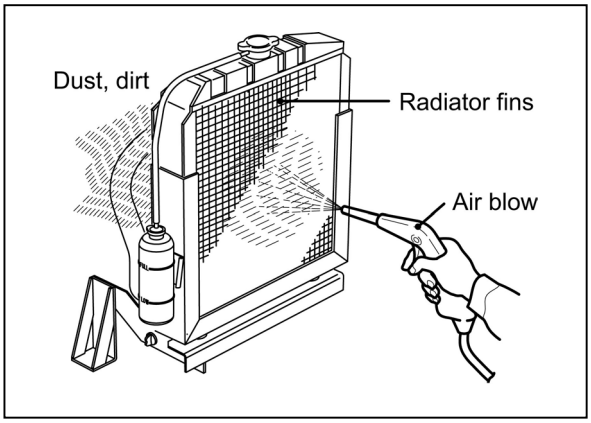
⚠ CAUTION

Beware of dirt from air blowing

Wear protective equipment such as goggles to protect your eyes when blowing compressed air. Dust or flying debris can hurt eyes.

Dirt and dust adhering on the radiator fins reduce the cooling performance, causing overheating. Make it a rule to check the radiator fins daily and clean as needed.

- Blow off dirt and dust from fins and periphery with compressed air [0.19MPa (2kgf/cm^2) or less] not to damage the fins with compressed air.
- If contaminated heavily, apply detergent, thoroughly clean and rinse with tap water shower.

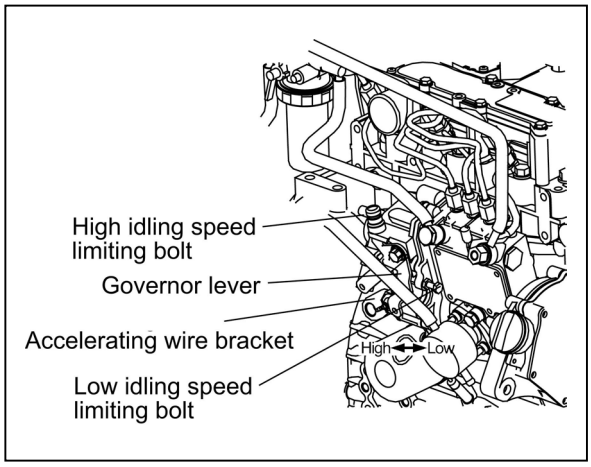


IMPORTANT:
Never use high pressure water or air from close by fins or never attempt to clean using a wire brush. Radiator fins can be damaged.

(3) V-belt tension check (The second time and after)

Check and adjust the V-belt tension. Refer to 2.2.2(2).

(4) Inspection and adjustment of governor lever and accelerator



The governor lever and accelerating devices (accelerating lever, pedal, etc.) of the machine unit are connected by an accelerating wire or rod. If the wire becomes stretched or the connections loose, the deviation in the position may result and make operation unsafe. Check the wire periodically and adjust if necessary.
Do not strongly move the accelerating wire or accelerating pedal. It may deform the governor lever

or stretch the wire to cause irregular engine speed control.
Checking and adjusting procedure are as follows.

1) Check that the governor lever of the engine makes uniform contact with the high idling and low idling limiting bolt when the accelerating devices is in the high idling speed or low idling speed position.
2) If either the high or the low idling speed side does not make contact with the limiting bolt, adjust the accelerating wire.
   Loosen the accelerating wire fixing nut and adjust the wire to contact with the limiting bolt.

⚠ CAUTION

Never release the limiting bolts. It will impair the safety and performance of the product and functions and result in shorter engine life.

(5) Air cleaner cleaning and element replacement

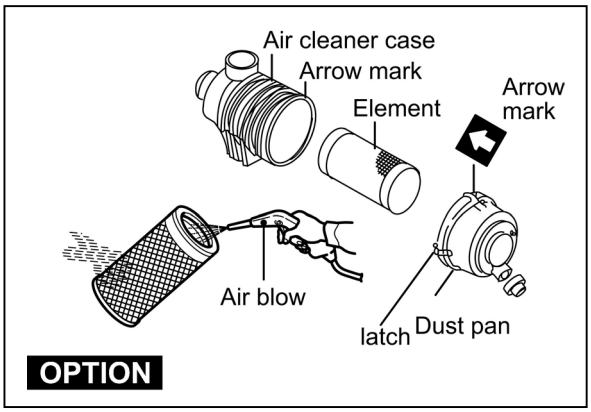
⚠ CAUTION

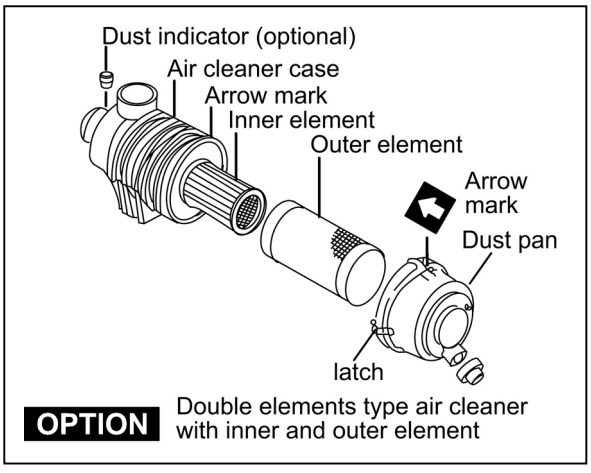
Beware of dirt from air blowing

Wear protective equipment such as goggles to protect your eyes when blowing compressed air. Dust or flying debris can hurt eyes.

The engine performance is adversely affected when the air cleaner element is clogged by dust. So periodical cleaning after disassembly is needed.

1) Undo the latches on the dust pan and remove the dust pan.
2) And pull out the element.
3) Blow air [0.29∼0.49MPa (3.0∼5.0kgf/cm^2)] from inside the element to blow dust off as shown in the illustration right.
   Apply the air blowing pressure as low as possible so as not to damage the element.
   If having the air cleaner with double elements, never remove and clean the inner element.
   The aim of installing the inner element is for back up protecting from intaking dust during engine running when leaving the outer element to reinstall after removing it or when damaging the outer element unexpectedly during engine running.
4) Replace the element with new one, if the element is damaged, excessively dirty or oily.
5) Clean inside of the dust pan.
6) Reinstall the element inserting into the air cleaner. And install the dust pan to the air cleaner case matching the arrow marks or the dust pan and air cleaner case, then fasten the dust pan with the latches.





IMPORTANT:

- When the engine is operated in dusty conditions, clean the element more frequently.
- Do not run the engine with removed air cleaner or element, as this may cause foreign material to enter and damage the engine.

2.2.5 Inspection every 500 hours or 6 months

Be sure to check the following points every 500 hours or 6 months operation, whichever comes first.

No.	Inspection Item
(1)	Water separator cleaning
(2)	Fuel filter element replacement
(3)	Air cleaner cleaning and element replacement

(1) Air cleaner element replacement

The cup of an water separator is translucent, and the inside can be seen. The floate ring rises when water collects at the bottom of the cup.
Periodically wash the water separator element and inside cup with clean fuel oil.

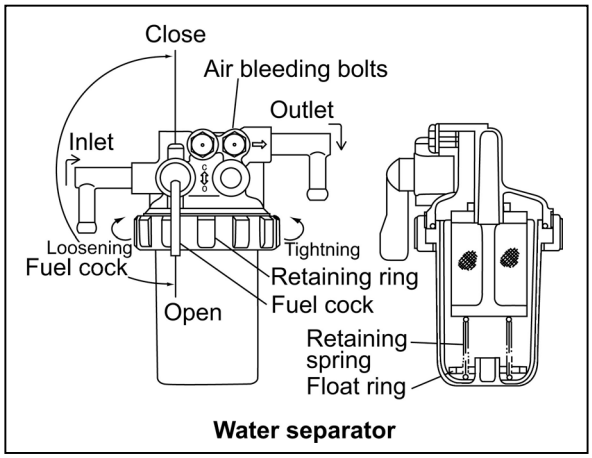
1) Close the fuel cock.
2) Loosen the retaining ring and remove the cup. Take the water and trash in the cup out.
3) Wash the element with clean fuel oil. Replace the element with new one if any damaged.

Element Part No.
129335-55700

4) Insert the element to the bracket and put the float ring and spring in the cup. Tighten the retaining ring.

   Tightening torque: 13～16Nm (1.3～1.6kgf-m)

5) Bleed the fuel system. Refer to 2.2.3(3)



Water separator

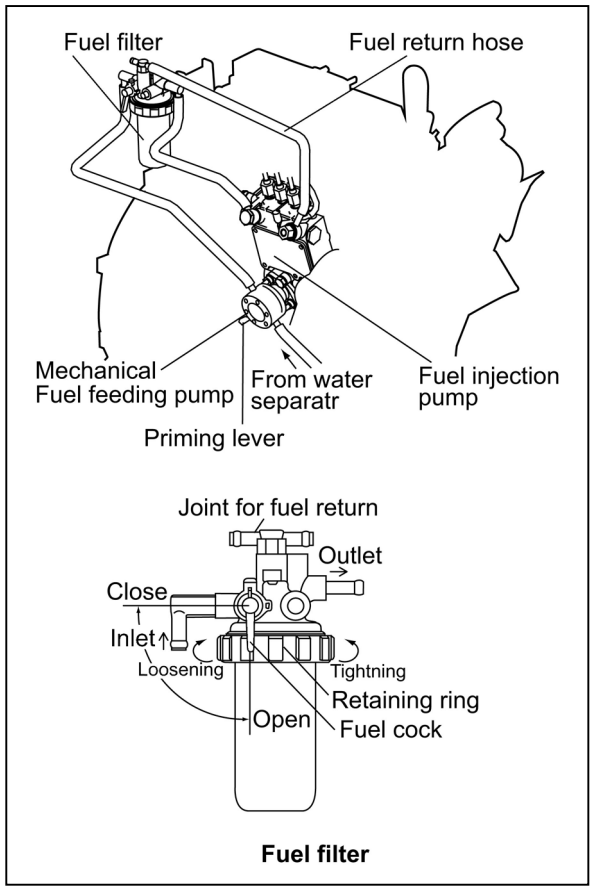
(2) Fuel filter element replacement

Replace the fuel filter element at specified intervals before it is clogged with dust to advesely affect the fuel flow. Do this work after an engine gets cold fully.

1) Close the fuel filter cock.
2) Loosen the retainer ring and replace the fuel filter element. Take the water and trash in the cup out.
   When removing the fuel filter, hold the bottom of the fuel filter with a piece of rag to prevent the fuel oil from dropping. If you spill fuel, wipe such spillage carefully.
3) Install a new fuel filter element and tighten the retainer ring.

   Tightening torque: 13～16N･m(1.3～1.6kgf･m)

Fuel filter element Part No.
119740-55650



Fuel filter

4) Bleed the fuel system. Refer to 2.2.3.(3)

IMPORTANT:
Be sure to use genuine Yanmar part. Otherwise, it results in engine damage, uneven engine performance and decline of engine life.
And, these troubles are outside the guarantee.

(3) Air cleaner cleaning and element replacement

Refer to 2.2.4(5).
Replace the air cleaner element periodically even if it is not damaged or dirty.
When replacing the element, clean inside of the dust pan at the time.
If having the air cleaner with double elements, do not remove the inner element. If the engine output is still not recover (or the dust indicator still actuates if having the air cleaner with a dust indicator) even though the outer element has replaced with new one, replace the inner element with new one.

2.2.6 Inspection every 1,000 hours or one year

Be sure to check the following points every 1,000 hours or one year operation, whichever comes first.

No.	Inspection Item
(1)	Cooling water replacement
(2)	Diaphragm assy inspection
(3)	Intake/exhaust valve clearance adjustment
(4)	Fuel injection nozzle pressure inspection

(1) Cooling water replacement

Cooling water contaminated with rust or water scale reduces the cooling effect. Even when antifreeze agent (LLC) is mixed, the cooling water gets contaminated due to deteriorated ingredients. Replace the cooling water at least once a year. Fill the radiator and coolant recovery tank with the cooling water as following.

1) Remove the radiator cap.

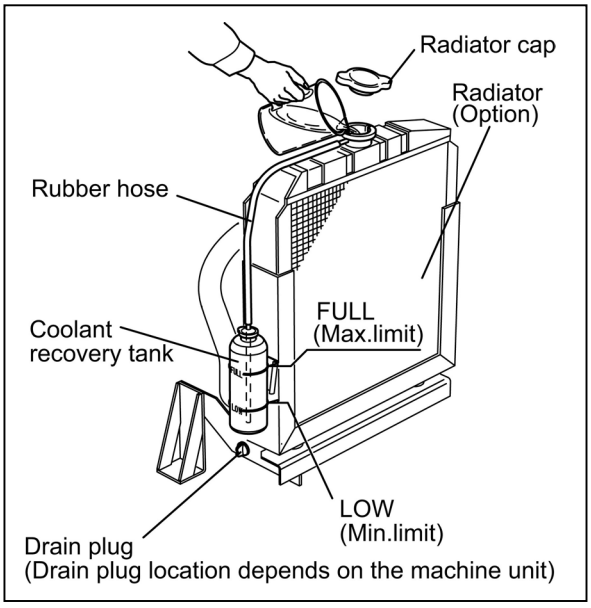
⚠ WARNING

- Never open the radiator filler cap while the engine and radiator are still hot. Steam and hot water will spurt out and seriously burn you. Wait until the radiator is cooled down after the engine has stopped, wrap the filler cap with a rag piece and turn the cap slowly to gently release the pressure inside the radiator.
- Securely tighten the filler cap after checking the radiator. Steam can spurt out during operation, if the cap is tightened loosely.

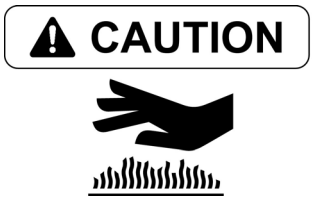
2) Loosen the drain plug at the lower portion of the radiator and drain the cooling water.

3) After draining the cooling water, tighten the drain plug.

4) Fill radiator and engine with cooling water. Refer to 3.4
   a) Before filling, check to be sure the drain plug is closed.
   b) Remove the radiator cap of the radiator by turning the radiator cap counter-clockwise about 1/3 of a turn.
   c) Pour the cooling water slowly into the radiator up to the lip of the filler port so that air bubbles do not develop.
   d) After supplying the cooling water, surely tighten the radiator cap. To fasten the radiator cap, align the detents on the back face of the radiator cap with the slot of the filler port and turn clockwise pushing it downward approx. 1/3 of a turn until contact with each other.
   e) Remove the cap of the coolant recovery tank, supply the cooling water to the FULL mark and fasten the cap.
   f) Check the rubber hose connecting the coolant recovery tank to the radiator. Be sure the rubber is securely connected and there is no looseness or damage. When the rubber hose is not water tight, an excessive amount of cooling water will be consumed.



g) When filling with the cooling water for the first time or replacing, the air contains in the cooling water system. So as the air in the cooling water system is made self-bleeding during engine operation, the cooling water level in the radiator and coolant recovery tank will be lowered. Replenish the cooling water into the radiator and coolant recovery tank until it reaches the FULL mark of the coolant recovery tank.



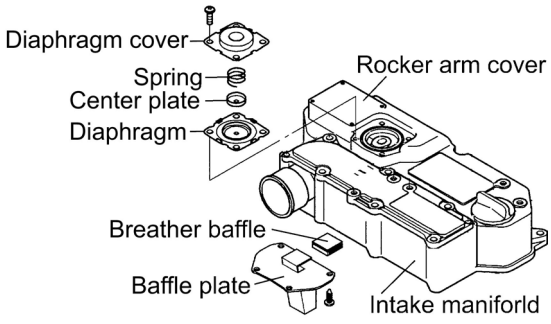
Beware of scalding by hot water

Wait until the temperature goes down before draining the cooling water. Otherwise, hot water may splash to cause scalding.

(2) Diaphragm assy inspection

Inspect the diaphragm assy on the rocker arm cover every 1000 hours or **2 years,** whichever comes first. Refer to 4.2.4 point 6 for the function of the diaphragm.

1) Loosen screws, and remove a diaphragm assy, and check whether oil and so on doesn't enter between the diaphragm and the cover. If oil and so on enters into the diaphragm assy, the diaphragm doesn't work well.
2) Check the damages of the diaphragm rubber and the spring. If necessary, replace with new ones.



Breather system componert

[NOTICE]

- When a diaphragm is damaged, pressure control inside the crankcase becomes insufficient, and troubles such as combustion defect and so on occur.
- At lube oil replacement or lube oil supply the amount of lube oil isn't to be beyond the standard upper limit. If the lube oil quantity is beyond the upper limit or an engine is operated beyond the allowable maximum angle of an engine, the amount of oil mist may be inducted in the combustion chamber and the oil hammer sometimes may occur.

(3) Intake/exhaust valve clearance adjustment

Make measurement and adjustment while the engine is cold.

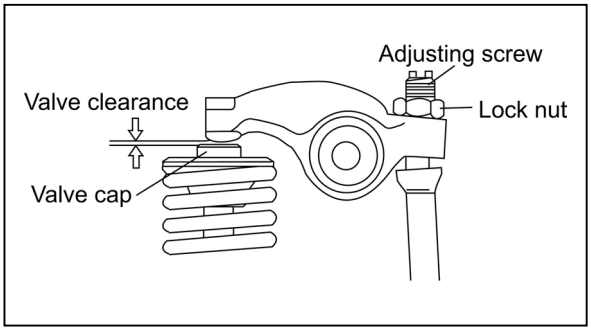
(a) Valve clearance measurement

1) Remove the rocker arm cover above cylinder head.
2) Set the No.1 cylinder in the compression TDC
   Turn the crankshaft to bring the piston of the No.1 cylinder to its compression top dead center while watching the rocker arm motion, timing scale and the top mark position of the crankshaft pulley. (Position where both the intake and exhaust valves are closed.)

Notes:

- The crankshaft shall be turned clockwise as seen from the radiator side.
- The No.1 cylinder position is on the opposite side of the radiator.
- Since there is a clearance between the rocker arm and valve at the compression top dead center, the position of TDC can be checked by hand. Also see that the top mark on the crankshaft pulley aligns with the mark on the gear case. If there is no valve clearance, disassemble and inspect around the valve seat, since the valve seat may be worn abnormally.

3) Valve clearance measurement
Insert a thickness gage between the rocker arm and valve cap and record the measured valve clearance.
(Use it as data for estimating the wear state.)



4) Adjusting other cylinders
Then in case of 3-cylinder engines turn the crankshaft clockwise viewed from radiator side at 240 degree, and adjust the valve clearance for the No.3 cylinder. Then adjust the No.2 cylinders in this order.

In case of 2-cylinder engines turn the crankshaft clockwise at 180 degree with 1 turn after the No.1 cylinder's adjustment.
The cylinder to be adjusted first does not have to be the No.1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make adjustment for other cylinders in the order of ignition by turning the crankshaft.

A adjustment method of reducing the flywheel turning numbers for 3 cylinder engines (for reference):

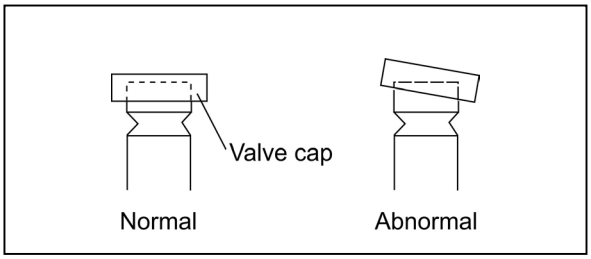
Set No.1 cylinder to the compression T.D.C. and adjust the clearance of the ● mark of the bottom table. Next, turn the flywheel once (the suction / exhaust valve of No.1 cylinder is in the position of the overlap T.D.C at this time), and adjust the clearance of the ○ mark.

Ignition order of 3 cylinder engines: 1⟶3⟶2

Cylinder No.	1		2		3		
Valve	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	
No.1 compression T.D.C	●	●	●			●	The first time
No.1 overlap T.D.C				○	○		The second time

(b) Valve clearance inspection and adjustment

1) Loosen the lock nut and adjusting screw, and check the valve for any inclination of valve cap, dirt or wear.



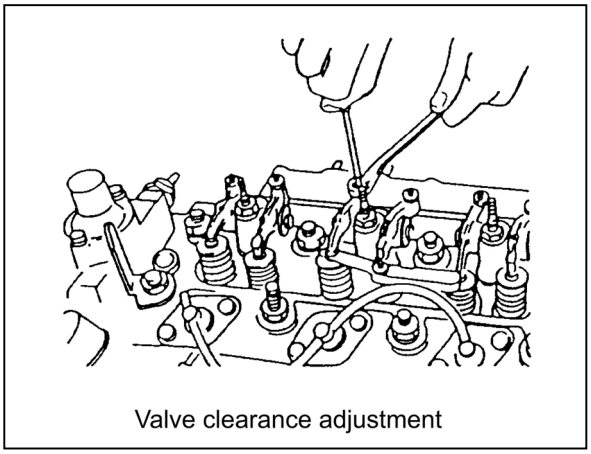
2) Insert a 0.2 mm thickness gage between the rocker arm and valve cap, and adjust the valve clearance. Tighten the adjusting screw.

mm

Standard valve clearance
0.15∼0.25

3) Apply oil to the contact surface between adjusting screw and push rod.

4) Adjust the other cylinder(s) in the order.



Valve clearance adjustment

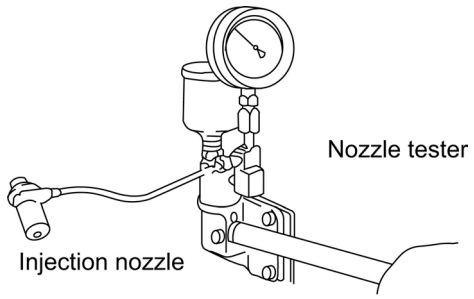
(4) Fuel injection nozzle pressure inspection

⚠ WARNING

Wear protective glasses when testing injection from the fuel injection valve. Never approach the injection nozzle portion with a hand. The oil jetting out from the nozzle is at a high pressure to cause loss of sight or injury if coming into careless contact with it.

(a) Injection pressure measurement

Standard Mpa(kgf/cm^2)
11.8～12.8 (120-130)



Injection pressure measurement with nozzle tester

[NOTICE]

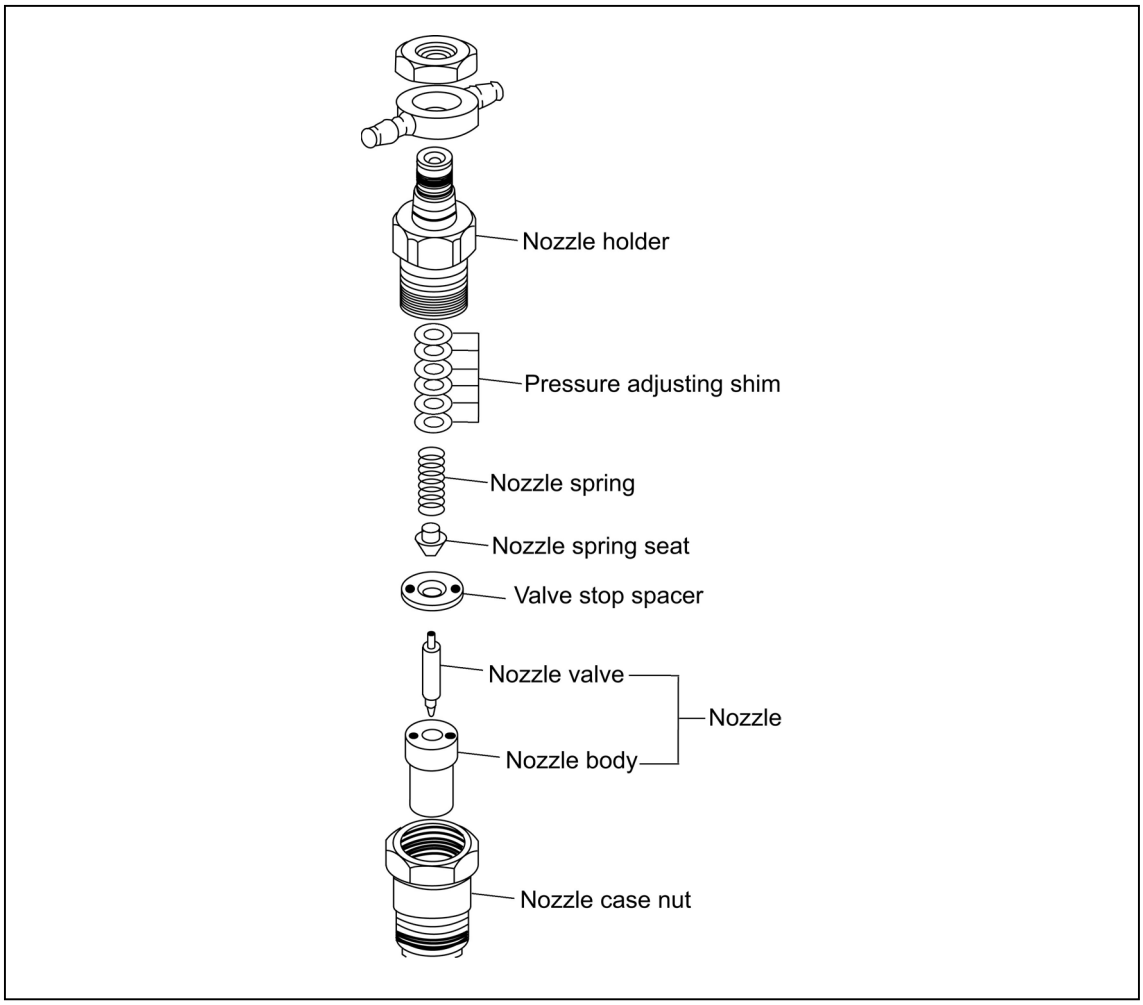
As for the opening pressure of the brand-new fuel nozzle, about 0.5MPa(5kgf/cm) declines by the engine operation for about 5 hours because of the initial wear-out of a spring etc. Therefore, adjust 0.5MPa(5kgf/cm) higher than the standard value of the above table when adjusting a new fuel nozzle of a spare part.

Remove carbon deposit at the nozzle hole thoroughly before measurement.

1) Connect the fuel injection valve to the high pressure pipe of the nozzle tester.
2) Operate the nozzle tester lever slowly and read the pressure at the moment when the fuel injection from the nozzle starts.
3) If the measured injection pressure is lower than the standard level, replace the pressure adjusting shim with a thicker one.

Thickness of pressure adjusting shims mm	Injection pressure adjustment
0.1, 0.2, 0.3, 0.4, 0.5	The injection pressure is increased by approx. 6.9～9.8MPa (7～10kgf/cm^2), when the adjusting shim thickness is increased by 0.l mm.

[Informative: Fuel injection valve structure]



(b) Spray pattern inspection

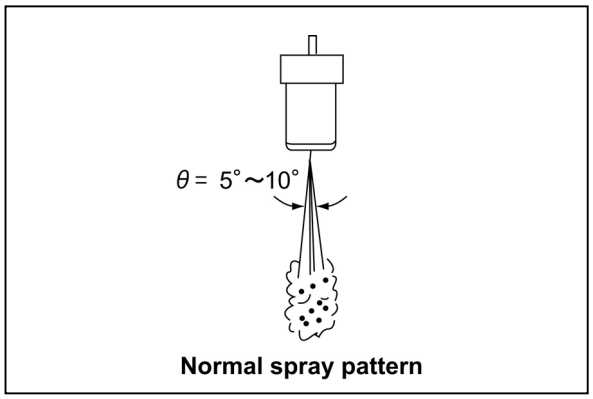
After adjustment to the specified valve opening pressure, use a nozzle tester and check the spray pattern and seat oil-tightness.

Seat oil tightness check

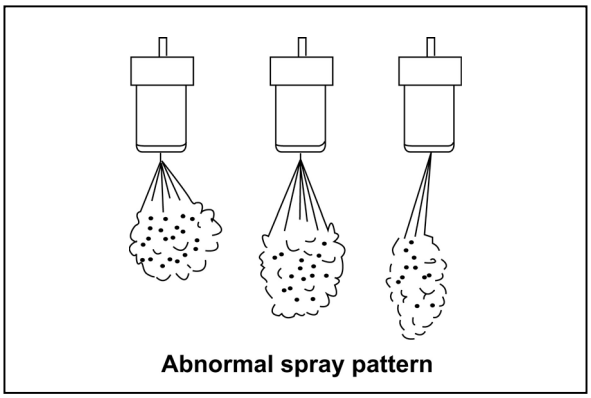
- After injecting a few times, increase the pressure gradually. Hold the pressure for about 5 seconds at a little before the valve opening pressure of 1.96 Mpa(20kgf/cm^2), and check to see that oil does not drip from the tip end of the nozzle.
- If extreme oil leak from the overflow joint exists during injection by the nozzle tester, check after retightening. If much oil is leaking, replace the nozzle assembly.

Spray and injection states

- Operate the nozzle tester lever at a rate of once or twice a second and check no abnormal injection.
- If normal injection as shown below cannot be obtained, replace the fuel injection valve.
- No extreme difference in angle(θ)
- Finely atomized spray
- Excellent spray departure



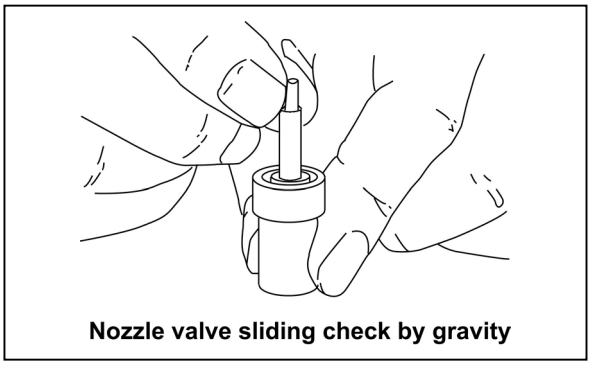
Normal spray pattern



Abnormal spray pattern

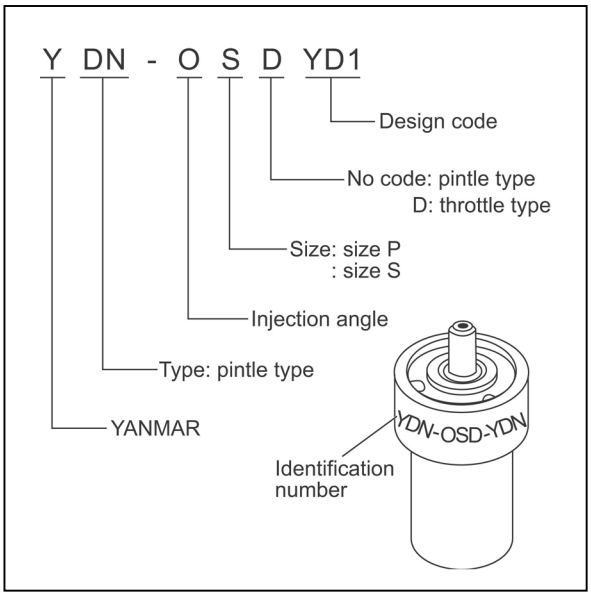
(c) Nozzle valve sliding test

Wash the nozzle valve in clean fuel oil. Place the nozzle body vertically and insert the nozzle into the body to about 1/3 of its length. The valve is normal if it smoothly falls by its own weight into the body. In case of a new nozzle, remove the seal peel, and immerse it in clean diesel oil or the like to clean the inner and outer surfaces and to thoroughly remove rust-preventive oil before using the nozzle. Note that a new nozzle is coated with rust-preventive oil and is pasted with the seal peel to shut off outer air.



Nozzle valve sliding check by gravity

(d) Nozzle punch mark



2.2.7 Inspection every 2000 hours or 2 years

Be sure to check the following points every 2,000 hours or two years operation, whichever comes first.

No.	Inspection Item
(1)	Cooling water path flushing and maintenance
(2)	Fuel pipe and cooling water pipe inspection and maintenance
(3)	Intake/exhaust valve seat lapping
(4)	Fuel injection timing adjustment Fuel injection pump inspection and adjustment

(1) Cooling water path flushing and maintenance

Rust and water scale will accumulate in the cooling system through many hours of operation. This lowers the engine cooling effect. Oil coolers (attached to turbocharged engines and some of naturally aspirated engines) guickly deteriorate the lube oil. The cleaning and maintenance of the following parts are necessary in accordance with the cooling water replacement.
Cooling system parts: radiator, cooling water pump, thermostat, cylinder block, cylinder head, oil cooler.

(2) Fuel pipe and cooling water pipe inspection and maintenance

Regularly check the rubber hoses of the fuel system and cooling water system. If cracked or degraded, replace them with new one. Replace the rubber hoses at least every 2 years even if 2,000 hours doesn't come.

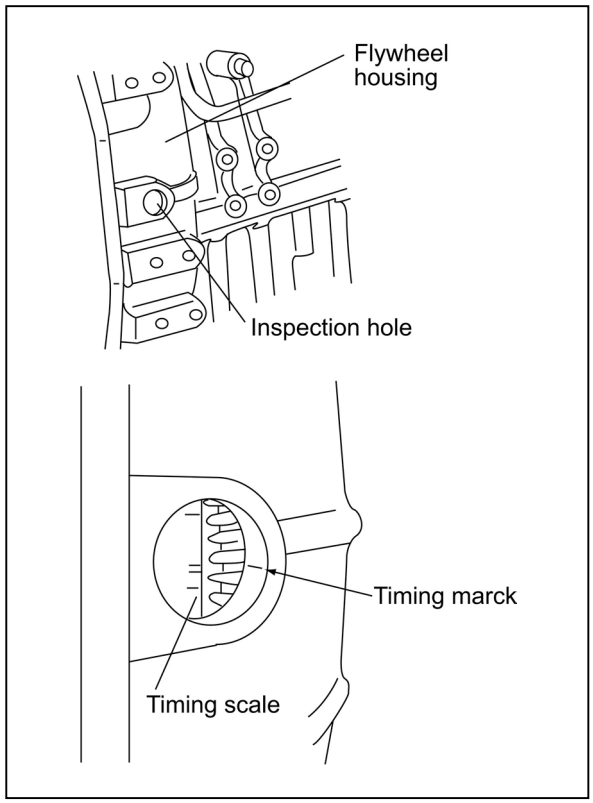
(3) Intake/exhaust valve seat lapping

The adjustment is necessary to maintain proper contact of the valves and seats. Refer to 4.2.6 in Chapter 4.

(4) Fuel injection timing adjustment / Fuel injection pump inspection and adjustment

The fuel injection timing and the fuel injection pump are adjusted so that engine performance may become the best condition. As for the inspection and adjustment of the fuel pump, it is based on the service manual of the ML pump of the separate volume. The fuel injection timing is adjusted by the following procedure.

1) Complete air bleeding from the fuel line and set the engine ready for starting.
2) See that the timing marks on fuel pump mounting flange and gear case are aligned.
3) Set the speed control lever at the operating position.
4) Disconnect the injection pipe on the fuel pump side for the No.1 cylinder. (Do not remove the delivery holder.)
5) Check the fuel discharge from the delivery holder while turning the crankshaft clockwise as seen from the radiator, and stop turning it at the same time when the fuel comes out. Wipe out the fuel of the delivery holder exit. Next, turn the crankshaft in the opposite direction (counterclockwise), and return it to about 20 degrees before top dead center.
6) Check again the fuel discharge from the delivery holder while turning the crankshaft clockwise, and stop turning it at the same time when the fuel comes out.



7) Read the timing scale on the flywheel from the hole on the flywheel housing. It is standard fuel injection timing if the timing mark position meets the fuel injection timing of the below table.

Model name	Class		VM				CH	VH	
	Engine speed	min^{-1}	2000 ～ 2100	2200	2300 ～ 2600	2700 ～ 3000	3000 / 3600	3100 ～ 3400	3500 ～ 3600
2TNV70	Injection timing (FID)bTDC ±1 deg.	Deg.	15		16	18	-	-	-
3TNV70			15		16	18	21	20	21
3TNV76			15	16		18	21	20	21

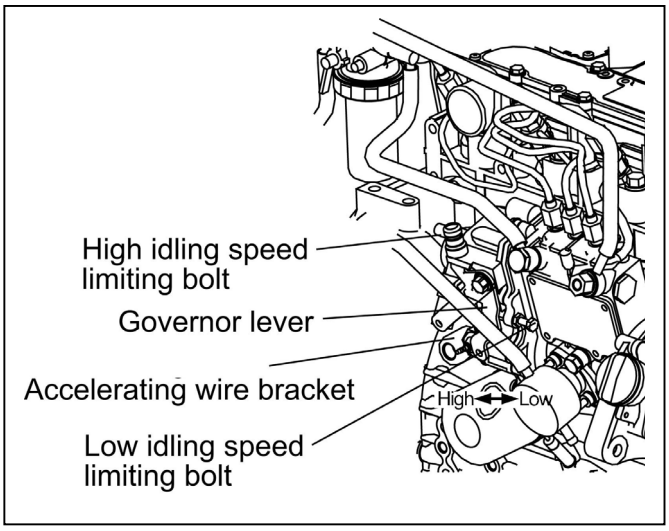
8) Repeat steps 5) to 7) a few times.

Note:
Injection timing check for one cylinder is generally sufficient. If it is to be checked for all cylinders of 3-cylinder engine, check each cylinder in the ignition order of: 1-3-2-1 by turning at each 240 degrees.
The cylinder to be checked is not limited to the No.1 cylinder and any cylinder may be checked.

9) If the injection timing is out of the standard value, loosen the fuel pump mounting nut and incline the fuel injection pump toward or away from the engine for adjustment. Incline toward the engine to delay the timing, and away from the engine to advance it.
(One graduation of the timing scale on gear case corresponds to two degrees in injection timing.)

2.3 Adjusting the no-load maximum or minimum speed

1) After warming the engine up, gradually raise the speed and set it at the no-load maximum speed.
2) If the no-load maximum revolution is out of the standard, adjust it by turning the high idle limiting bolt.
3) Then set the no-load minimum speed by adjusting the low idle limiting bolt.



Standards (Unit: min^{-1})

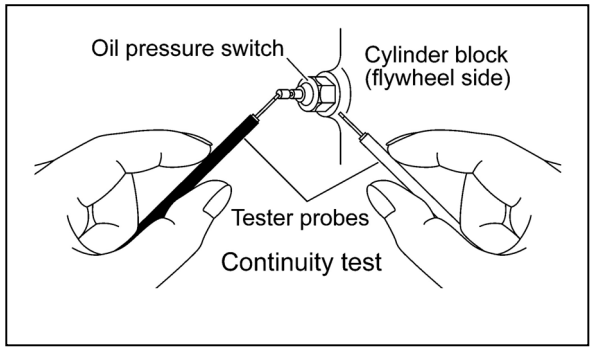
Engine application class	Rating speed	No-load maximum (±25)	No-load minimum (±25)
VM	2000	2160	800
	2100	2250	
	2200	2355	
	2300	2460	
	2400	2570	
	2500	2675	
	2600	2780	
	2700	2890	
	2800	2995	
	2900	3100	
	3000	3210	
CH	3000	-	1500
	3600	3800	
VH	3100	3290	800
	3200	3400	
	3300	3500	
	3400	3600	
	3500	3710	
	3600	3815	

Note) The engine speed may differ from the above standard depending on an engine installed on a machine unit.

2.4 Sensor Inspection

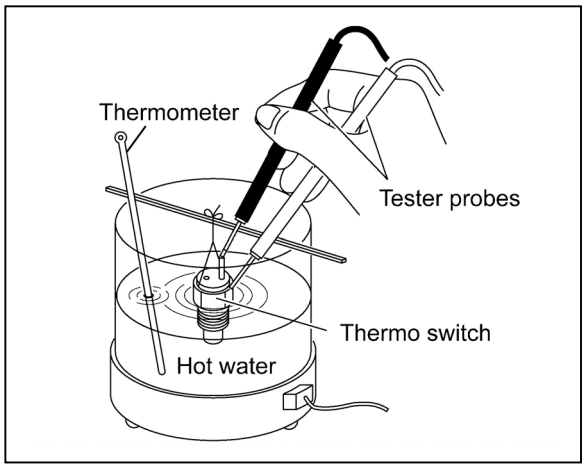
2.4.1 Oil pressure switch

Disconnect the connector from the oil pressure switch. Keep the voltammeter probes in contact with the switch terminal and cylinder block while operating the engine. It is abnormal if circuit is closed.



2.4.2 Thermo switch

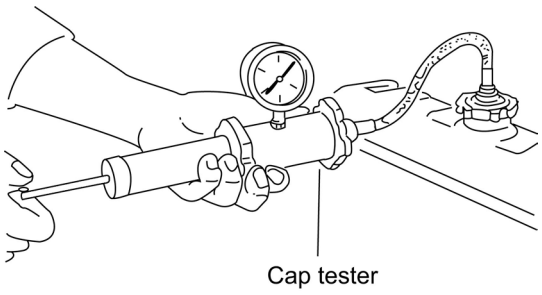
Place the thermo switch in a container filled with antifreeze or oil. Heat it while measuring the fluid temperature. The switch is normal if the voltammeter shows continuity when the fluid temperature is 107-113 deg C.



2.5 Water leak check in cooling water system

Check cooling water leakage from the cooling water system visually. If any problem is found, Inspect as follows.

1) Fill cooling water to the normal level in the radiator, and install the cap tester on the radiator.
2) Operate the manual pump to set the pressure to 0.09±0.015MPa (0.9±0.15kgf/cm^2). If the cap tester pressure gage reading drops then, water is leaking from the cooling water system. Check the water leaking point.



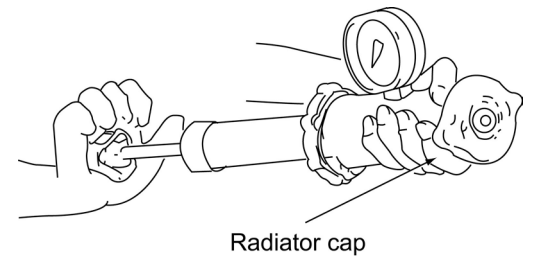
Water leak check in cooling water system

2.6 Radiator cap inspection

Spread water on the seal surface of the radiator cap fully, and install the cap to a cap tester. Raise the pressure of the tester, and check that the valve of the cap opens by the standard pressure.

Standard pressure	0.09±0.015MPa (0.9±0.15kgf/cm^2)

When the cap doesn't open, it is abnormal. Replace the cap with new one.



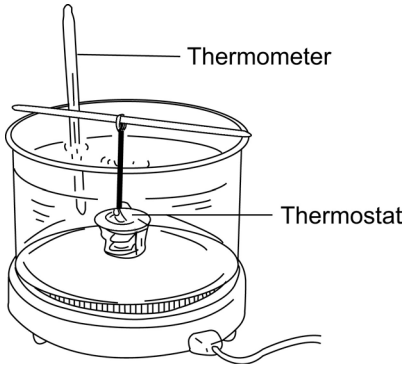
Radiator cap inspection

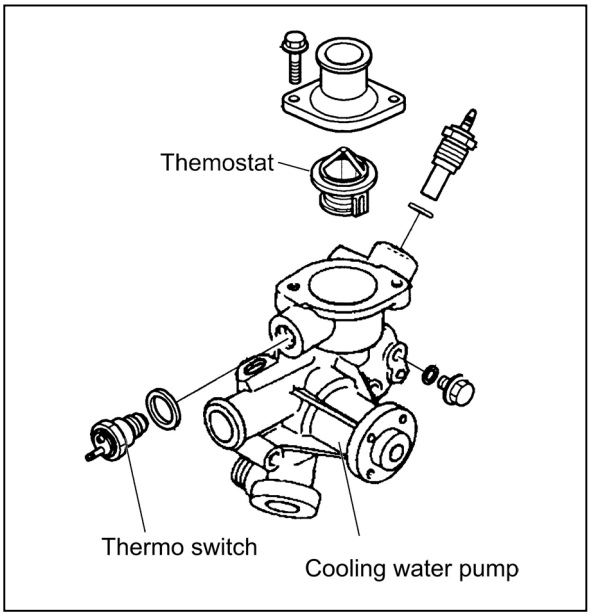
2.7 Thermostat inspection

Place the thermostat in a container filled with water. Heat it while measuring the water temperature, and see that the thermostat is actuated at temperature of following table.

Valve opening Temperature (deg C)*	Full open lift (Temperature) (mm)
69.5～72.5	8 or more (85deg C)

* Valve opening temperature is carved on the flange.





2.8 Adjusting Operation

Perform the adjusting operation of a engine as follows after the maintenance job:

1) Supply the fuel oil, lube oil and cooling water.

Note:
Check the levels of the lube oil and cooling water again after test running (for about 5 minutes) and add as required.

2) Start the engine, and carry out idling at the low speed (700 to 900 rpm) for a few minutes.
3) Run in the engine for about five minutes at the rated revolution (no-load). Check any water, fuel or oil leak and existence of abnormal vibration or noise. Also check the oil pressure, cooling water temperature and exhaust gas color.
4) Adjust the no-load minimum and maximum revolutions. (Refer to 2.3 in chapter 2.)
5) Perform loaded operation as required.

2.9 Long storage

Observe the following instructions when the engine is to be stored for a long period without operation:

1) Be sure to use clean soft water added Long Life Coolant Antifreeze (LLC) in the cooling water system and do not drain the coolant before long-term storage.
If drain the cooling water, it will cause to built up rust due to the residual water in the cooling water system.

2) Remove the mud, dust and oil deposit and clean the outside.

3) Perform the nearest periodic inspection before the storage.

4) Drain or fill the fuel oil fully to prevent condensation in the fuel tank.

5) Disconnect the battery cable from the battery negative (-) terminal.

6) Cover the silencer, air cleaner and electric parts with PVC cover to prevent water and dust from depositing or entrance.

7) Select a well-ventilated location without moisture and dust for storage.

8) Perform recharging once a month during storage to compensate for self-discharge.

9) When storing an engine for long time, run the engine or do motoring periodically according to the following procedure because the rust occurrence inside the engine, the rack agglutination of the fuel pump, and so on are likely to occur. (In case that the engine is equipped with a machine unit,)

a) Replace the lube oil and the filter before the engine running.
b) Supply fuel if the fuel in the fuel tank was removed, and bleed the fuel system.
c) Confirm that there is the coolant in the engine.
d) Operate the engine at the low idling speed for about five minutes. (If it can be done, one a month)

3. TROUBLESHOOTING

3.1 Preparation before troubleshooting

If the signs of a trouble appear, it is important to lecture on the countermeasure and treatment before becoming a big accident not to shorten the engine life.

When the signs of a trouble appear in the engine or a trouble occurs, grasp the trouble conditions fully by the next point and find out the cause of sincerity according to the troubleshooting. Then repair the trouble, and prevent the recurrence of the trouble.

1) What's the occurrence phenomenon or the trouble situation? ····· (e.g. Poor exhaust color)

2) Investigation of the past records of the engine
Check a client control ledger, and examine the history of the engine.

- Investigate the engine model name and the engine number. (Mentioned in the engine label.)
  Examine the machine unit name and its number in the same way.
- When was the engine maintained last time?
- How much period and/or time has it been used after it was maintained last time?
- What kind of problem was there on the engine last time, and what kind of maintenance was done?

3) Hear the occurrence phenomenon from the operator of the engine in detail.

5W1H of the occurrence phenomenon : the investigation of when (when), where (where), who (who), what (what), why (why) and how (how)

- When did the trouble happen at what kind of time?
- Was there anything changed before the trouble?
- Did the trouble occur suddenly, or was there what or a sign?
- Was there any related phenomenon.
  ·····.(e.g. Poor exhaust color and starting failure at the same time)

4) After presuming a probable cause based on the above investigation, investigate a cause systematically by the next troubleshooting guide, and find out the cause of sincerity.

3.2 Quick Reference Table for Troubleshooting

The following table summarizes the general trouble symptoms and their causes. If any trouble symptom occurs, take corrective action before it becomes a serious problem so as not to shorten the engine service life.

	Trouble symptom / Cause	Starting failure				Insufficient engine output			Poor exhaust color		High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	Hunting		Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Lube oil				Much blow-by gas	Cooling water		Air intake		Exhaust temperature rise	Corrective action
			Engine starts but stops soon.			Exhaust color			During work																					
			Exhaust smoke																											
		Engine does not start.	None	Little	Much	Ordinary	White	Black	White	Black				During idling	During work				Excessive consumption	Dilution by fuel oil	Mixture with water	Low L.O. pressure		Overheat	Low water temperature	Pressure drop	Pressure rise		
Engine system	Improper clearance of intake/exhaust valve	○	○			○						○														○		○	Adjust the valve clearance. (See 2.2.6(3) in Chapter2.)
	Compression leakage from valve seat					○		○		○		○						○					○			○		○	Lap the valve seat. (See 4.2.6 in Chapter4.)
	Seizure of intake/exhaust valve	○			○	○		○		○		○			○	○				○			○			○			Correct or replace.
	Blowout from cylinder head gasket					○															○			○					Replace the gasket. (See 4.2.2-11) in Chapter4.)
	Seized or broken piston ring	○			○		○		○			○		○		○			○	○			○	○				○	Replace the piston ring. (See 4.4.2-5), 10) in Chapter4.)
	Worn piston ring, piston or cylinder	○			○		○		○										○	○			○						Perform honing and use oversize parts. (See 4.4.5-(1),(4) and 4.4.6 in Chapter4.)
	Seized crankpin metal or bearing	○	○									○		○	○	○							○						Repair or replace.
	Improper arrangement of piston ring joints		○				○												○				○						Correct the ring joint positions. (See 4.4.4 point 6 in Chapter4.)
	Reverse assembly of piston rings						○		○										○				○						Reassemble correctly. (See 4.4.4 point 6 in Chapter4.)
	Worn crankpin and journal bearing					○						○		○	○	○						○							Measure and replace. (See 4.4.5-(2) in Chapter4.)
	Loosened connecting rod bolt											○				○						○							Tighten to the specified torque. (See 4.4.4-point 2 in Chapter4.)
	Foreign matter trapped in combustion chamber	○										○							○				○						Disassemble and repair.
	Excessive gear backlash											○																	Adjust gear meshing. (See 4.3.4-point 2 in Chapter4.)
	Worn intake/exhaust valve guide						○												○				○						Measure and replace. (See 4.2.5-(2) and 4.2.7 in Chapter4.)
	Defective governor		○											○	○	○	○												Make adjustment.
	Improper open/close timing of intake/exhaust valves	○					○	○	○	○		○																	Adjust the valve clearance. (See 2.2.6-(3) in Chapter2.)

Cause	Trouble symptom	Starting failure: Engine does not start.	Starting failure: Engine starts but stops soon. – Exhaust smoke: None	Starting failure: Engine starts but stops soon. – Exhaust smoke: Little	Starting failure: Engine starts but stops soon. – Exhaust smoke: Much	Insufficient engine output – Exhaust color: Ordinary	Insufficient engine output – Exhaust color: White	Insufficient engine output – Exhaust color: Black	Poor exhaust color – During work: White	Poor exhaust color – During work: Black	High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	Hunting: During idling	Hunting: During work	Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Lube oil: Excessive consumption	Lube oil: Dilution by fuel oil	Lube oil: Mixture with water	Lube oil: Low L.O. pressure	Much blow-by gas	Cooling water: Overheat	Cooling water: Low water temperature	Air intake: Pressure drop	Air intake: Pressure rise	Exhaust temperature rise	Corrective action
Cooling water System	Excessive cooling effect of radiator								○								○							○				Defective thermostat (kept closed) (See 2.7 in Chapter2.)
	Insufficient cooling effect of radiator							○															○				○	Defective thermostat (kept opened)(See 2.7 in Chapter2.) or slipping fan belt (See 2.2.2-(2) in Chapter2.)
	Insufficient cooling water level							○															○				○	Check water leakage from cooling water system. (See 2.2.1-(1)(4)(5) in Chapter2.)
	Cracked water jacket																			○	○		○					Repair or replace.
	Slackened fan belt							○															○				○	Adjust the belt tension. (See 2.2.2-(2) in Chapter2.)
	Defective thermostat							○	○														○	○				Check or replace. (See 2.7 in Chapter2.)
Lubricating System	Improper properties of lube oil	○	○			○												○			○	○						Use proper lube oil. (See 1.3.2 in Chapter1.)
	Leakage from lube oil piping system																	○			○							Repair.
	Insufficient delivery capacity of trochoid pump																				○							Check and repair. (See 5.5 in Chapter5.)
	Clogged lube oil filter																				○	○						Clean or replace.
	Defective pressure regulating valve																				○							Clean, adjust or replace.
	Insufficient lube oil level		○																		○							Add proper lube oil. (See 2.2.1-(3) in Chapter2.)
Fuel system	Too early timing of fuel injection pump								○	○	○					○												Check and adjust. (See 2.2.7-(4) in Chapter2.)
	Too late timing of fuel injection pump						○	○	○	○							○										○	Check and adjust. (See 2.2.7-(4) in Chapter2.)
	Improper properties of fuel oil					○	○	○	○	○			○															Use proper fuel oil. (See 1.3.1 in Chapter1.)
	Water entrance in fuel system	○			○		○		○				○	○	○													Drain from the fuel system. (See 2.2.3 (1)(2) and 2.2.5(1)(2) in Chapter2.)
	Clogged fuel filter	○	○			○																						Clean or replace. (See 2.2.5(2) in Chapter2.)
	Air entrance in fuel system	○	○			○																						Perform air bleeding. (See 2.2.3(3) in Chapter2.)
	Clogged or cracked fuel pipe	○	○			○																						Clean or replace.
	Insufficient fuel supply to fuel injection pump	○	○			○																						Check the fuel tank cock, fuel filter, fuel pipe, and fuel feed pump.
	Uneven injection volume of fuel injection pump						○	○	○	○			○	○	○	○											○	Check and adjust.
	Excessive fuel injection volume									○							○	○				○	○			○	○	Check and adjust.
	Poor spray pattern from fuel injection nozzle						○	○	○	○			○	○	○	○		○										Check and adjust. (See 2.2.6(4) in Chapter2.)
	Priming failure	○																										Foreign matter trapped in the valve inside the priming pump. (Disassemble and clean.)
	Clogged strainer at feed pump inlet					○																						Clean the strainer.

	Trouble symptom / Cause	Starting failure: Engine does not start.	Starting failure: Engine starts but stops soon. — Exhaust smoke: None	Starting failure: Engine starts but stops soon. — Exhaust smoke: Little	Starting failure: Engine starts but stops soon. — Exhaust smoke: Much	Insufficient engine output — Exhaust color: Ordinary	Insufficient engine output — Exhaust color: White	Insufficient engine output — Exhaust color: Black	Poor exhaust color — During work: White	Poor exhaust color — During work: Black	High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	Hunting: During idling	Hunting: During work	Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Lube oil: Excessive consumption	Lube oil: Dilution by fuel oil	Lube oil: Mixture with water	Lube oil: Low L.O. pressure	Much blow-by gas	Cooling water: Overheat	Cooling water: Low water temperature	Air intake: Pressure drop	Air intake: Pressure rise	Exhaust temperature rise	Corrective action
Air/Exhaust Gas System	Clogged air filter				○			○		○			○												○				Clean. (See 2.2.4(5) and 2.2.5(3) in Chapter2.)
	Engine used at high temperatures or at high altitude							○		○							○						○		○				Study output drop and load matching.
	Clogged exhaust pipe							○		○			○														○		Clean.
Electrical System	Starting motor defect	○																											Repair or replace. (See Chapter8.)
	Alternator defect	○																											Repair or replace. (See Chapter9.)
	Open-circuit in wiring	○																											Repair. (See Chapter10.)
	Battery voltage drop	○																											Inspect and change the battery. (See 2.2.3(4) in Chapter2.)

3.3 Troubleshooting by measuring Compression Pressure

Compression pressure drop is one of major causes of increasing blowby gas (lube oil contamination or increased lube oil consumption as a resultant phenomenon) or starting failure. The compression pressure is affected by the following factors:

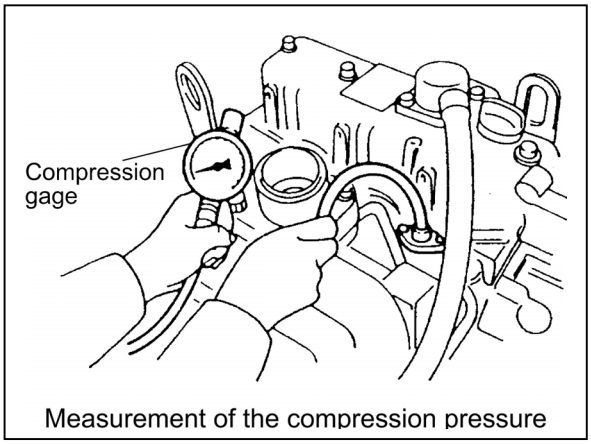
1) Degree of clearance between piston and cylinder
2) Degree of clearance at intake/exhaust valve seat
3) Gas leak from nozzle gasket or cylinder head gasket

In other words, the pressure drops due to increased parts wear and reduced durability resulting from long use of the engine.
A pressure drop may also be caused by scratched cylinder or piston by dust entrance from the dirty air cleaner element or worn or broken piston ring. Measure the compression pressure to diagnose presence of any abnormality in the engine.

(1) Compression pressure measurement method

1) After warming up the engine, remove the fuel injection pipe and valves from the cylinder to be measured.
2) Crank the engine before installing the compression gage adapter.

*1) Perform cranking with the stop handle at the stop position (no injection state).
*2) See 4.1.2(2)-No.18 in Chapter 4 for the compression gage and compression gage adapter.



Measurement of the compression pressure

3) Install the compression gage and compression gage adapter at the cylinder to be measured.
*1)Never forget to install a gasket at the tip end of the adapter.

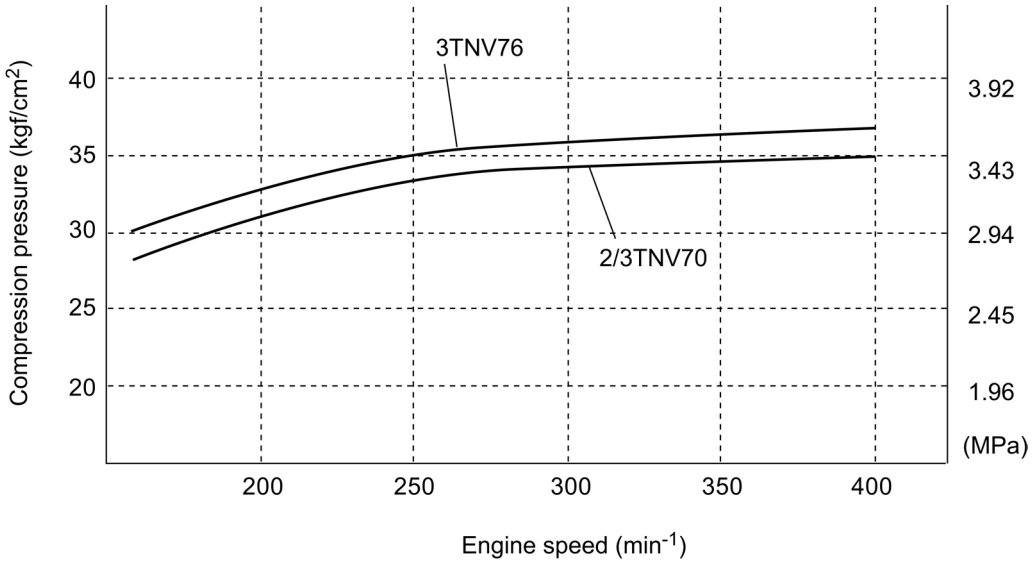
4) With the engine set to the same state as in 2)*1), crank the engine by the starter motor until the compression gage reading is stabilized.

(2) Standard compression pressure

Engine compression pressure list (reference value)

Engine mode	Compression pressure at 250 min^{-1} MPa (kgf/cm^2)		Deviation among cylinders MPa (kgf/cm^2)
	Standard	Limit	
2/3TNV70	3.24±0.1 (33±1)	2.55±0.1 (26±1)	0.2～0.3 (2～3)
3TNV76	3.43±0.1 (35±1)	2.75±0.1 (28±1)	0.2～0.3 (2～3)

(3) Engine speed and compression pressure (for reference)



(4) Measured value and troubleshooting

When the measured compression pressure is below the limit value, inspect each part by referring to the table below.

No.	Item	Cause	Corrective action
1	● Air cleaner element	● Clogged element ● Broken element ● Defect at element seal portion	● Clean the element. ● Replace the element.
2	● Valve clearance	● Excessive or no clearance	● Adjust the valve clearance. (See 2.2.6(3) in Chapter 2.)
3	● valve timing	● Incorrect valve clearance	● Adjust the valve clearance. (See 2.2.6(3) in Chapter 2.)
4	● Cylinder head gasket	● Gas leak from gasket	● Replace the gasket. ● Retighten the cylinder head bolts to the specified torque. (See 4.2.4 point 8 in Chapter 4.)
5	● Intake/exhaust valve ● Valve seat	● Gas leak due to worn valve seat or foreign matter trapping ● Sticking valve	● Lap the valve seat. (See 4.2.6 in Chapter 4.) ● Replace the intake/exhaust valve.
6	● Piston ● Piston ring ● Cylinder	● Gas leak due to scratching or wear	● Perform honing and use an oversized part. (See 4.4.5 and 4.4.6 in Chapter 4.)

4. Disassembly, Inspection and Reassembly of Engines

4.1 Complete disassembly and reassembly

4.1.1 Introduction

Make preparation as follows before starting engine inspection and service:

1) Fix the engine on a horizontal base.

⚠ WARNING

Be sure to fix the engine securely to prevent injury or damage to parts due to falling during the work.

2) Remove the cooling water hose, fuel oil pipe, wire harness, control wires etc. connecting the driven machine and engine, and drain cooling water, lube oil and fuel.

3) Clean soil, oil, dust, etc. from the engine by washing with solvent, air, steam, etc. Carefully operate so as to prevent any foreign matter from entering the engine.

⚠ WARNING

Always wear glasses or other protectors when using compressed air or steam to prevent any foreign matter from getting in the eyes.

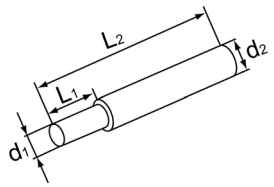
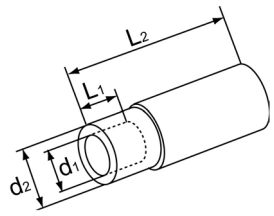
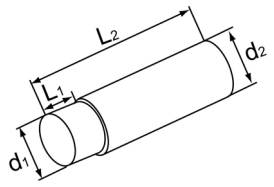
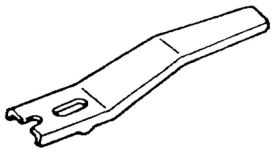
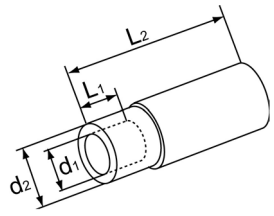
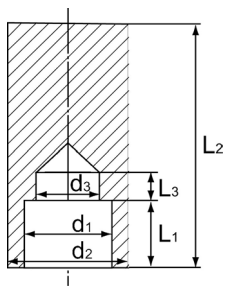
[NOTICE]

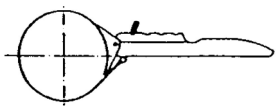
- Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit shall be replaced.
- Any part predicted to dissatisfy the standard or limit before the next service as estimated from the state of use should be replaced even when the measured value then satisfies the standard or limit.

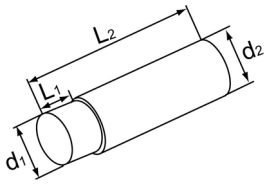
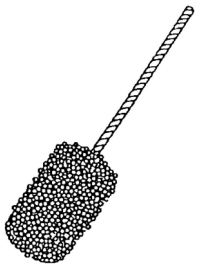
4.1.2 Special service tools

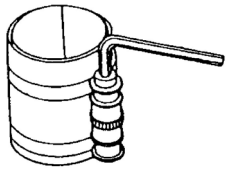
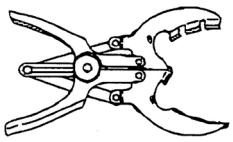
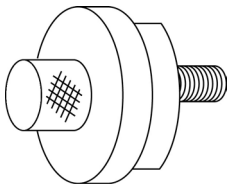
Although main engine parts can be disassembled and reassembled only with standard service toots. It is recommended to provide the following special service tools and measuring instruments for more efficient and accurate work. correct measurement, diagnosis, and troubleshooting.

(1) Special Tools

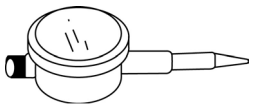
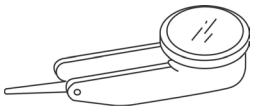
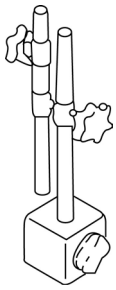
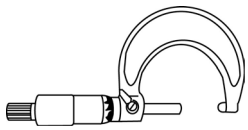
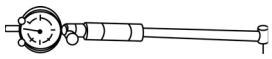
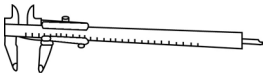
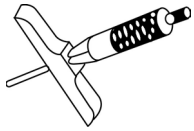
<table>
<tr><th>No.</th><th>Tool name</th><th>Applicable model and tool size</th><th>Illustration</th></tr>
<tr><td>1</td><td>Valve guide tool
(for extracting valve guide)</td><td>mm
<table><tr><td>L1</td><td>L2</td><td>d 1</td><td>d 2</td></tr><tr><td>20</td><td>75</td><td>5.5</td><td>9.5</td></tr></table>※Locally manufactured</td><td>  </td></tr>
<tr><td>2</td><td>Valve guide tool
(for inserting valve guide)</td><td>mm
<table><tr><td>L1</td><td>L2</td><td>d1</td><td>d 2</td></tr><tr><td>10</td><td>60</td><td>11</td><td>17</td></tr></table>Tolerance: $L1^{0}_{-0.3}$
※Locally manufactured</td><td>  </td></tr>
<tr><td>3</td><td>Connecting rod bushing replacer
(for removal / installation of connecting rod bushing)</td><td>mm
<table><tr><td>L1</td><td>L2</td><td>d 1</td><td>d2</td></tr><tr><td>25</td><td>85</td><td>22</td><td>25</td></tr></table>Tolerance: $d1^{-0.3}_{-0.6}$ $d2^{-0.6}_{-0.3}$
※Locally manufactured</td><td>  </td></tr>
<tr><td>4</td><td>Valve spring compressor
(for removal / installation of valve spring)</td><td>yanmar code No.
129100-92630</td><td>  </td></tr>
<tr><td>5</td><td>Stem seal inserter
(for inserting stem seal)</td><td>mm
<table><tr><td>d1</td><td>d2</td><td>d 3</td><td>L1</td><td>L2</td><td>L3</td></tr><tr><td>15.0</td><td>21</td><td>12</td><td>11.0</td><td>65</td><td>4 or more</td></tr></table>Tolerance: d1±0.2 L1±0.1
※Locally manufactured</td><td> 
  </td></tr>
</table>

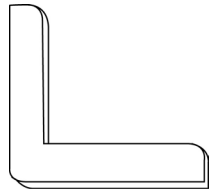
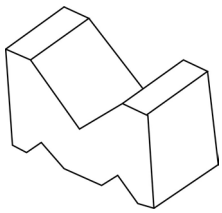
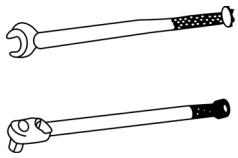
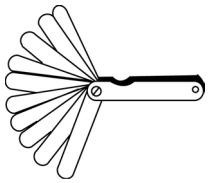
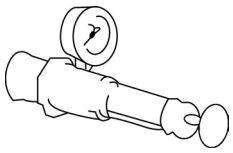
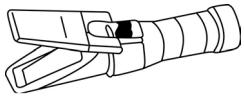
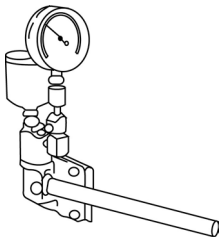
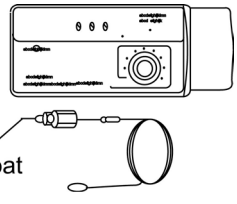
<table>
<tr><th>No.</th><th>Tool name</th><th>Applicable model and tool size</th><th>Illustration</th></tr>
<tr><td>6</td><td>Filter wrench
(for removal / installation of L.O. filter)</td><td>Available on the market</td><td>  </td></tr>
<tr><td>7</td><td>Camshaft bushing tool
(for extracting camshaft bushing)</td><td>mm
<table><tr><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr><tr><td>18</td><td>70</td><td>45</td><td>48</td></tr></table>
Tolerance: $d1^{-0.3}_{-0.6}$ $d2^{-0.6}_{-0.3}$

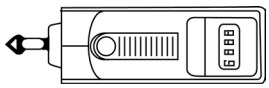
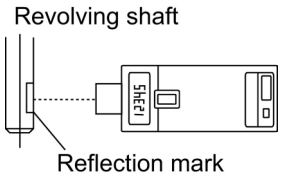
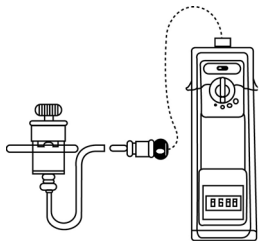
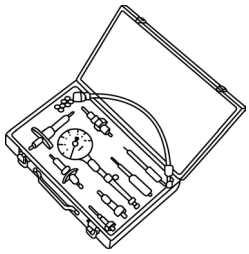
※Locally manufactured</td><td>  </td></tr>
<tr><td>8</td><td>Flex-Hone
(For re-honing of cylinder liner)</td><td>mm
<table><tr><th>Parts No.</th><th>Cylinder bore</th></tr><tr><td>129400-92410</td><td>70-76</td></tr></table></td><td>  </td></tr>
<tr><td>9</td><td>Piston insertion tool
(for inserting piston)</td><td>Yanmar code No. 955500-02476

※The above piston insertion tool is applicable to 60 –125 mm diameter pistons.</td><td>  </td></tr>
<tr><td>10</td><td>Piston ring replacer
(for removal / installation of piston ring)</td><td>Available on the market</td><td>  </td></tr>
<tr><td>11</td><td>Crankshaft pulley installing tool</td><td>Locally manufactured
(for 4TNV94L)
(Refer to 4.3.6 in detail)</td><td>  </td></tr>
</table>

(2) Measuring instruments

No.	Instrument name	Application	Illustration
1	Dial gage	Measurements of shaft bending, and strain and gap of surfaces	
2	Test indicator	Measurements of narrow or deep portions that cannot be measured by dial gage	
3	Magnetic stand	For holding the dial gage when measuring using a dial gage, standing angles adjustable	
4	Micrometer	For measuring the outside diameters of crankshaft, pistons, piston pins, etc.	
5	Cylinder gage	For measuring the inside diameters of cylinder liners, rod metal, etc.	
6	Vernier Calipers	For measuring outside diameters, depth, thickness and width	
7	Depth micrometer	For measuring of valve sink	

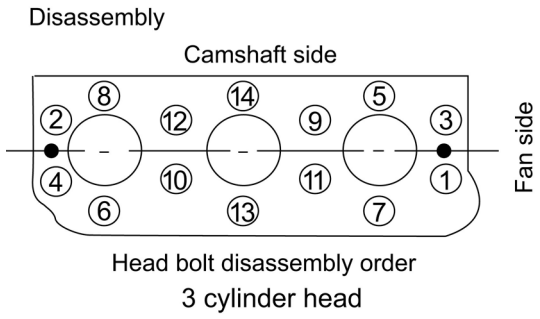
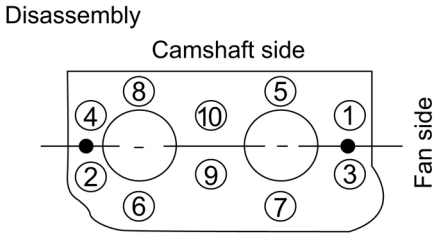
No.	Instrument name	Application	Illustration
8	Square	For measuring valve spring inclination and straightness of parts	
9	V-block	For measuring shaft bend	
10	Torque wrench	For tightening nuts and bolts to the specified torque	
11	Thickness gage	For measuring gaps between ring and ring groove, and shaft joints during assembly	
12	Cap tester	For checking water leakage	
13	Battery coolant tester	For checking concentration of antifreeze and the battery electrolyte charge status	
14	Nozzle tester	For measuring injection spray pattern of fuel injection nozzle and injection pressure	
15	Digital thermometer	For measuring temperatures	

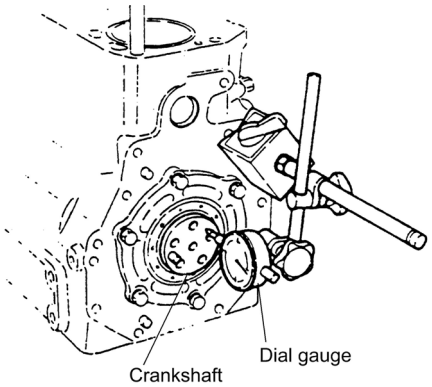
No.	Instrument name		Application	Illustration
16	Speedometer	Contact type	For measuring revolution by contacting the mortise in the revolving shaft	
		Photoelectric type	For measuring revolution by sensing the reflecting mark on the outer periphery of the revolving shaft	
		Fuel high-pressure pipe clamp type	For measuring the revolution regardless of the center or periphery of the revolving object.	
17	Circuit tester		For measuring resistance, voltage and continuity of electrical circuits	
18	Compression gage kit		For measuring compression pressure Yanmar code No. TOL-97190080	

4.1.3 Complete disassembly

Peripheral parts such as air cleaner, muffler and radiator differ in installation and types for each application. Therefore, description in this Chapter is started with the steps to be taken just after the peripheral parts have been removed.

Step	Removal Parts	Remarks
1	1) Thoroughly remove sand, dust, dirt and soil from the surface of the engine. 2) Drain cooling water and lube oil from the engine.	
2	1) Remove exhaust manifold. 2) Remove intake manifold.	
3	1) Close the fuel cock valve of the fuel tank. 2) Remove high-pressure fuel pipes. 3) Remove fuel return pipe. 4) Remove fuel injection nozzles *) Fuel injection nozzle for Indirect injection system is screwed type.	1) If nozzle seat is left in the cylinder head, remove the cylinder head before extracting nozzle seat. 2) To prevent dust from entering fuel injection nozzles, fuel injection pump and high-pressure fuel pipes, seal their respective threads with a tape or the like. 3) Whenever extracting fuel injection nozzle, replace nozzle protector with a new one.
4	1) Remove rocker arm cover assembly.	
5	1) Remove valve rocker arm shaft assembly. 2) Remove push rods.	1) Attach a tag to a push rod for each cylinder No. to put the push rods in order. 2) Remove valve cap from the intake/exhaust valve head. 3) Tappet can be removed at the same time when push rod is extracted. 4) Attach a tag to a tappet for each cylinder No. to put the tappets in order.
6	1) Remove fan mounting bolt, and then remove fan. 2) Loosen a adjusting bolt for the V-belt adjuster, and then remove V-belt. 3) Remove alternator. 4) Remove the spacer for cooling fan and V-pulley.	1) Never turn down alternator vigorously toward the cylinder block. Otherwise, your finger may be nipped and alternator broken.
7	1) Remove lube oil filter assembly. 2) Extract a dipstick from the oil dip-stick hole.	
8	1) Disconnect fuel return pipes. 2) Remove fuel filter.	
9	1) Disconnect cooling water pipe from the cooling water pump. 2) Remove thermostat assembly. 3) Remove cooling water pump.	

Step	Removal Parts	Remarks
10	1) Remove cylinder head tightening bolts. 2) Remove a cylinder head assembly. 3) Remove a cylinder head gasket.	1) Lay a cardboard or the like on the floor and place a cylinder head assembly on it so as not to damage the combustion surface. 2) The order of loosening the cylinder head tightening bolts.  Head bolt disassembly order 3 cylinder head  Head bolt disassembly order 2 cylinder head 3) To remove the intake/exhaust valves from cylinder head assembly, take the following steps. a) Using a valve spring compressor (see 4.1.2(1) No.4 in Chapter 4), compress a valve spring and remove a valve cotter. b) Remove valve retainer and valve spring. c) Remove intake valve and exhaust valve.
11	1) Remove crankshaft V-pulley clamping bolt. 2) Using a puller, extract crankshaft V-pulley.	1) Extract crankshaft V-pulley by hitting the bolt of the puller using a plastic hammer or the like.
12	1) Remove oil pan mounting bolts under a gear case. 2) Remove gear case mounting bolts. 3) Remove a gear case.	1) Never fail to removes stiffner bolt at the center of the gear case 2) When removing the gear case, carefully protect oil seal from damage.
13	1) Remove the nut from fuel injection pump drive gear. Extract the fuel injection pump drive gear using a puller.	1) Before removing fuel injection pump, make sure of the position of the arrow on the pump body for adjusting fuel injection timing as well as the position of the scribed line of the gear case flange.
14	1) Remove a lube oil pump.	
15	1) Remove a starting motor from flywheel housing.	

Step	Removal Parts	Remarks
16	1) Remove flywheel mounting bolts. 2) Remove a flywheel.	1) Carefully protect the ring gear from damage.
17	1) Remove a flywheel housing. 2) Remove a oil seal.	1) Carefully protect the oil seal from damage.
18	1) Put a cylinder block upside down and remove a oil pan and a spacer.	1) Carefully protect the combustion surface of the cylinder block from damage. 2) Be careful not to drop tappets off when the cylinder block is turned upside down, because the tappet is cylindrical in shape.
19	1) Remove a idle gear shaft, and then remove a idle gear. 2) Remove a mounting bolt of thrust bearing through the hole of the camshaft gear. Remove camshaft assembly.	1) Turn the cylinder block aside and carefully prevent tappet from jamming on the cam. 2) Preheat a camshaft gear and a camshaft assembly to 180°-200° before removing them, because they are shrink fitted.
20	1) Remove a gear case flange.	
21	1) Remove a lube oil strainer.	
22	1) While turning a crankshaft, place piston at the bottom dead center (BDC). 2) Remove the crankpin cap of a connecting rod.	1) Remove carbon deposits from the upper wall of the cylinder using fine sandpaper before extracting pistons. Take care not to damage the inner surface of the cylinder. 2) Make sure that the cap No. of connecting rod meets the cylinder No. 3) Take care not to drop the crankpin metal when removing the crankpin cap of the connecting rod.
23	1) Remove main bearing cap bolts. While shaking a main bearing cap, remove it together with the lower main bearing metal. 2) Extract a crankshaft, taking care not to damage it. 3) Remove upper main bearing metal.	1) Before extracting a crankshaft, measure the side gap of it.  Apply a dial gauge to the end of crankshaft. Force the crankshaft on both sides in the axial direction to measure the thrust gap.

Step	Removal Parts	Remarks
23		Alternatively, insert a thickness gauge directly between the base thrust metal and the thrust surface of the crankshaft to measure the gap. (Refer to 4.4.4 in Chapter 4.) If the measured gap exceeds the limit, replace the thrust metal with a new one. 2) Notice on the removal of thrust metal a) When removing thrust metal, ascertain the position and direction of thrust metal in relation to the cap. b) Make sure that the thrust metal groove is outward to the cap.
24	1) Remove pistons and connecting rod assemblies.	1) To selectively remove a desired piston and connecting rod assembly without extracting crankshaft, take the steps itemized below: a) Remove carbon deposits from the upper wall of the cylinder using fine sandpaper, taking care not to damage the inner surface of the cylinder. b) While turning the crankshaft, with the crankpin cap removed, raise the piston up to the top dead center (TDC). c) Extract the piston/connecting rod assembly while tapping the connecting rod at the large end with the handle of a plastic hammer or the like.
25	1) Remove tappets.	

4.1.4 Precautions before and during reassembly

To reassemble engine components, reverse the procedure of disassembly. However, follow the precautions below and the precautions from chapter 4 to chapter 7 particularly before and during reassembly.

(1) Cleaning the component

Use particular care to clean the cylinder block, cylinder head, crankshaft, and camshaft. Ensure that they are free from chips, dust, sand, and other foreign matter.

(2) Parts to be replaced during reassembly

Be sure to replace the following parts with new ones during assembly.

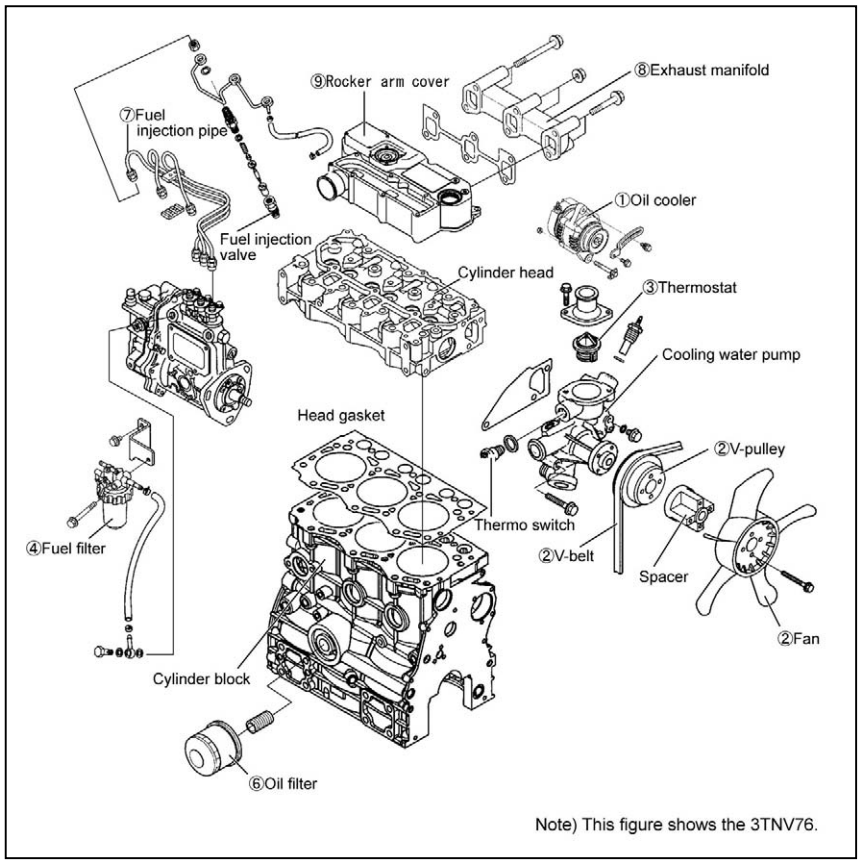
- Valve stem seal
- Head gasket packing
- Various copper packing, O-rings and gasket packing.

4.1.5 Adjusting operation

Make sure to perform adjusting operation after completing reassembly. Refer to section 2.8 in chapter 2 for the operation procedure.

4.2 Cylinder Head: Disassembly, Inspection and Reassembly

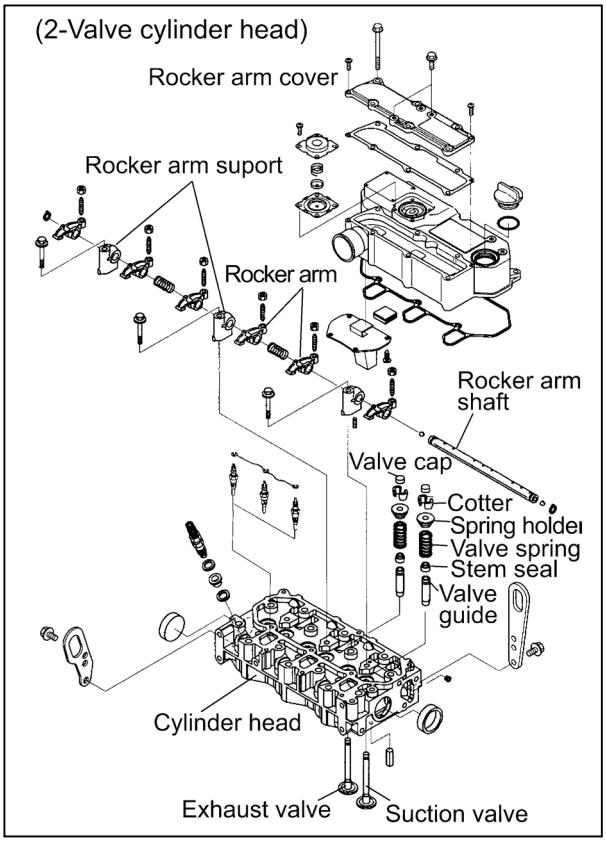
4.2.1 Components (2-valve cylinder head)



4.2.2 Disassembly procedure:

Disassemble in the order of the numbers shown in the illustration.

1) Remove the alternator assy. (Point1 of 4.2.4)
2) Remove the fan, pulley and V belt.
3) Remove the thermostat case. (Point2)
4) Remove the fuel filter and fuel oil piping. (Point3)
5) Remove the oil level gage.
6) Remove the oil filter. (Point4)
7) Remove the fuel injection pipes. (Point5)
8) Remove the exhaust manifold assy.
9) Remove the rocker arm cover Assy. (Point6)
10) Remove the rocker shaft assy, push rods and valve caps. (Point7)
11) Remove the cylinder head assy and head gasket. (Point8)
12) Remove the fuel injection valves and fuel return pipe. (Point9)
13) Remove the intake/exhaust valves, stem seals and valve springs. (Point10)
14) Remove the rocker arms from the rocker shaft.



4.2.3 Reassembly procedure:

Reverse order of the disassembly procedure.

4.2.4 Servicing points

Point 1

[Disassemble]

- Loosen the mounting bolt while supporting the alternator.

⚠ CAUTION

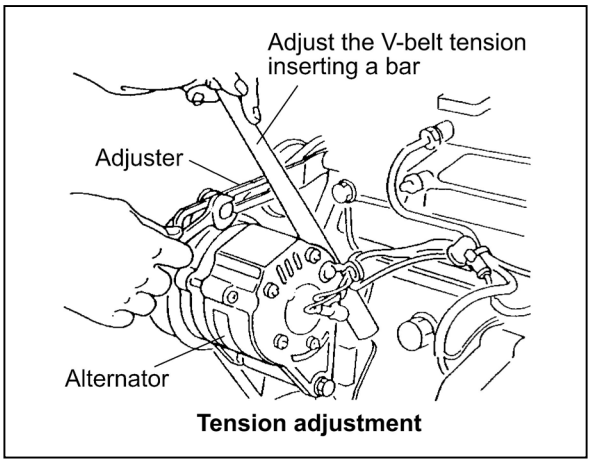
Do not tilt the alternator toward the cylinder block in haste since it may damage the alternator or pinch a finger.

[Reassemble]

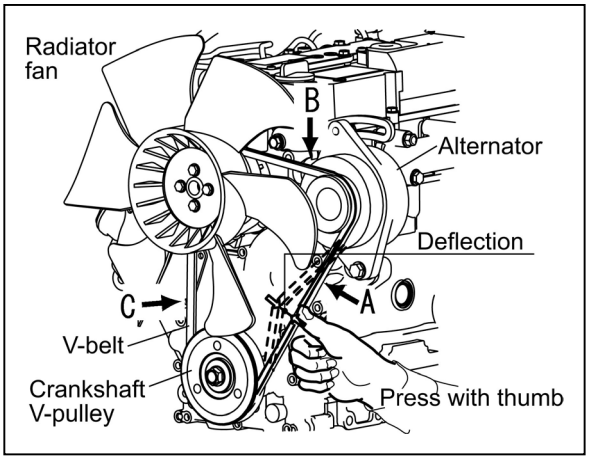
- The belt deflections A, B & C shall be checked according to 2.2.2(2). in Chapter2.

[Reassemble]

- Replace the belt with a new one if cracked, worn or damaged.
- Carefully prevent the belt from being smeared with oil or grease.



Tension adjustment



Point 2

[Reassemble]

- Check the thermostat function. (See 2.7 in Chapter 2 for the check procedure.)

Point 3

[Reassemble]

- Replace the fuel filter element with a new one.

[Disassemble]

- Cover the fuel pipe opening with tape to prevent intrusion of foreign matters.

Point 4

[Reassemble]

- Replace the oil filter with a new one.
- After fully tightening the filter manually, retighten it with a filter wrench (see 4.1.2(1) No.6 in Chapter 4) by 3/4 turn.

Point 5

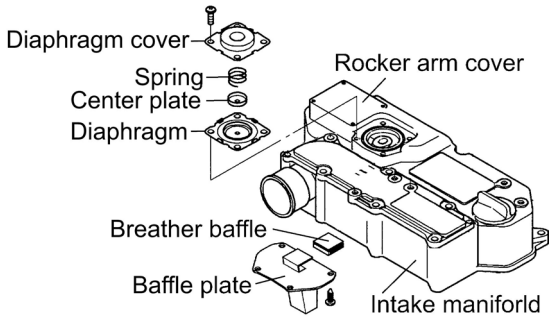
[Disassemble]

- Cover the fuel injection pipe and pump inlets and outlets with tape or the like to prevent intrusion of foreign matters.

Point 6

Breather system (A reductor to intake air system of blowby gas)

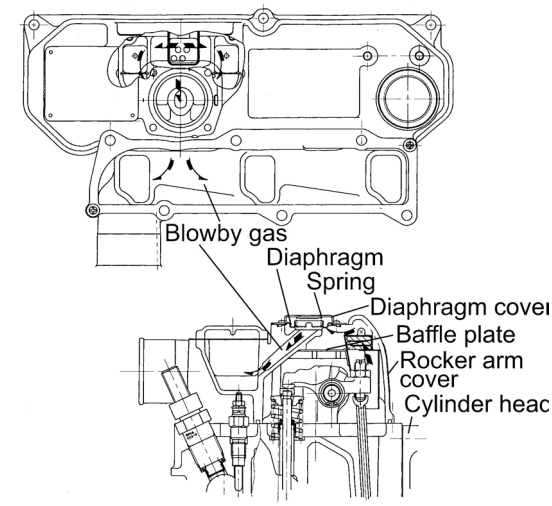
Emitting blowby gas is harmful to natural environment. Therefore blowby gas reductor is adopted to TNV series engines as breather system. The system of model 3TNV76 is shown as a representative of that breather system in the right figure. Some of the combustion gas passes through the clearance between the cylinder and the piston, piston ring, and flows to the crankcase. This is said as blowby gas. While it passes into the cylinder head and the rocker arm cover, the blowby gas mixes with splash oil, and becomes oil mist-blowby gas. Next, oil is separated from mist-blowby gas with passing through the baffle plate inside a rocker arm cover. And it passes through a diaphragm assy and a intake manifold, and is reduced in the combustion chamber. Pressure inside a crankcase is controlled by the function of the diaphragm assy, and suitable amount of blowby gas is reduced in intake air system.



Breather system componert

[Disassembly]

When a rocker arm cover is taken off, check whether oil or the like enter the diaphragm space from a small hole on the side of a diaphragm cover or not without disassembling the diaphragm.



Blowby gas flow

[NOTICE]

1) When a diaphragm is damaged, pressure control inside the crankcase becomes insufficient, and troubles occur. When the internal pressure of the crankcase decreases too much due to the damage of a spring, much blowby gas containing oil is reduced in intake air system, and it may cause the combustion defect by the early dirt of the intake valve or the urgent rotation of the engine by the oil burning.
When pressure progresses in the crank case too much due to the wrong operation of the diaphragm and so on, it is considered that oil leakage from the joint of a oil pan, a oil seal and so on will occur. When a diaphragm is damaged, blowby is discharged from the breathing hole on the side of diaphragm cover, and not reduced in the intake manifold. Therefore, be careful of the diaphragm trouble.

2) At lube oil replacement or lube oil supply
The amount of lube oil isn't to be beyond the standard upper limit (in the engine horizontality, the upper limit mark of the dip stick). Since the blowby gas reductor is adopted, be careful that the amount of oil mist may be inducted in the combustion chamber and the oil hammer sometimes may occur, when the lube oil quantity is beyond the upper limit or an engine is operated beyond the allowable maximum angle of an engine.

[Reassembly]

Replace the diaphragm with new one, when it is damaged.

Point 7

[Disassemble]

- Keep the removed push rods by attaching tags showing corresponding cylinder Nos.

[Reassemble]

- Always apply oil to the contact portions of the push rods and clearance adjusting screws.

Point 8

[Disassemble]

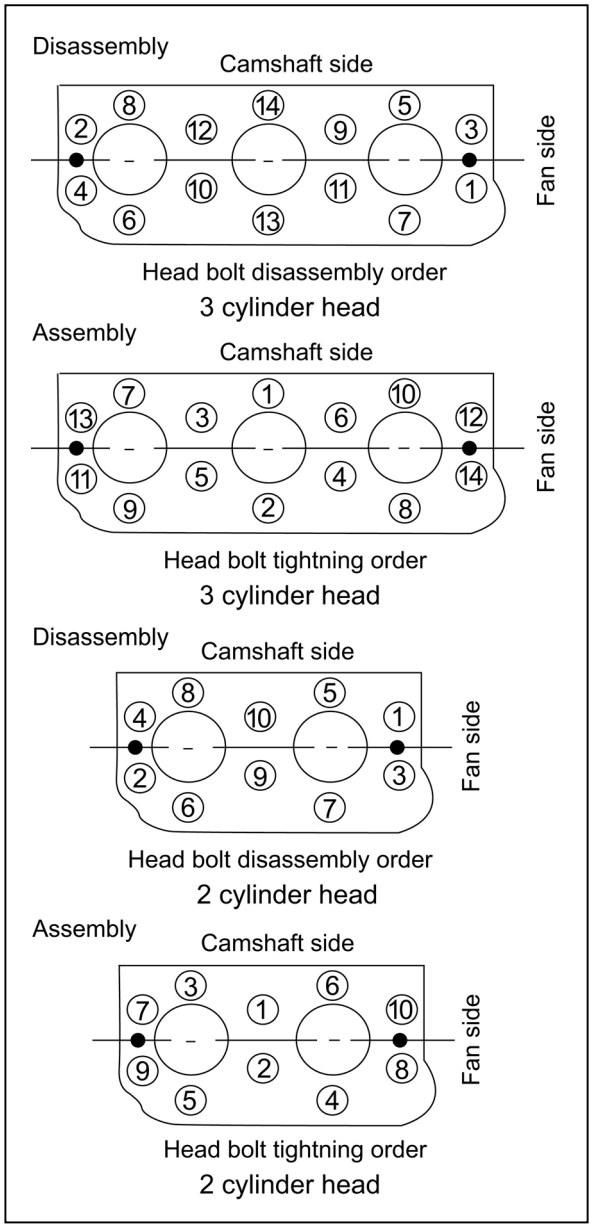
- Loosen the cylinder head bolts in two steps in the illustrated order.
- Place the cylinder head assy on a paper board to prevent the combustion face from any damage.

[Reassemble]

- Remove the head gasket with a new one.
- Uniformly install the head bolts manually after applying oil on the threaded and seat portions
- They shall be tightened in two steps in the reverse of the order for disassembly.

Nm(kgf･m)

	Tightening torque
First step	26.0～30.0 (2.7～3.1)
Second step	53.9～57.9 (5.5～5.9)



Point 9

[Disassemble]

- Carefully remove the fuel injection valve so as not to leave the top end protector from being left inside the cylinder.

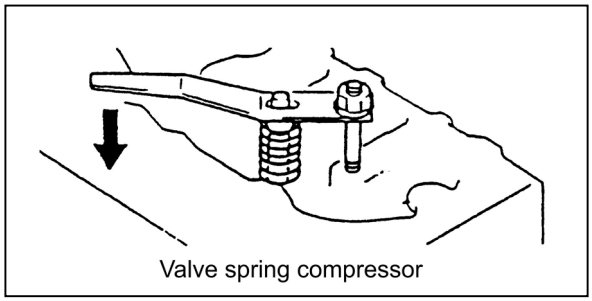
[Reassemble]

- Replace the fuel injection valve protector with a new one.

Point 10

[Disassemble]

- When removing each intake/exhaust valve from the cylinder head, use a valve spring compressor (see 4.1.2.No.4 in Chapter 4) and compress the valve spring and remove the valve cotter.)
- Keep each removed intake/exhaust valve after attaching a tag showing the corresponding cylinder No.
- If cotter burr is seen at the shaft of each intake/exhaust valve stem, remove it with an oilstone and extract the valve from the cylinder head.



[Reassemble]

- Replace the stem seal with a new one when an intake/exhaust valve is disassembled.
- Carefully install each valve after oil application so as not to damage the stem seal.
- Different stem seals are provided for the intake and exhaust valves. Do not confuse them since those for exhaust valves are marked with yellow paint.
- After assembling the intake/exhaust valve, stem seal, valve spring, seat, and cotter, tap the head of the valve stem lightly for settling.
- Do not forget to install the valve cap.

4.2.5 Parts Inspection and measurement

(1) Cylinder head

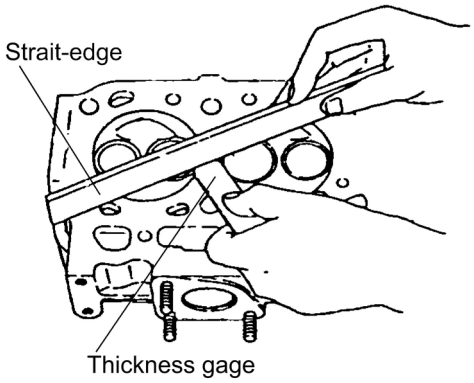
Clean the cylinder head, mainly the combustion surface, valve seats and intake/exhaust ports, remove carbon deposit and bonding agent, and check the surface state.

(a) Appearance check

Check mainly discoloration and crack. If crack is suspected, perform color check.

(b) Combustion surface distortion

Apply a strait-edge in two diagonal directions and on four sides of the cylinder head, and measure distortion with a thickness gage.



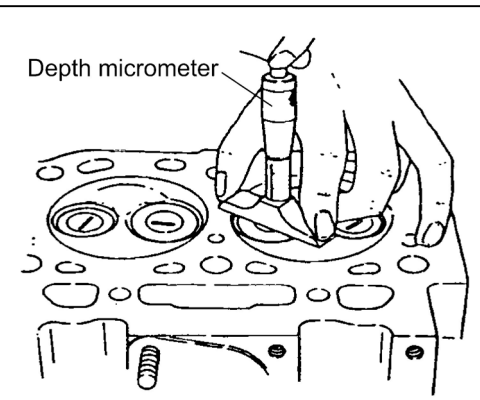
Distortion at combustion surface

mm

	Standard	Limit
Distortion	0.05 or less	0.15

(c) Valve sink

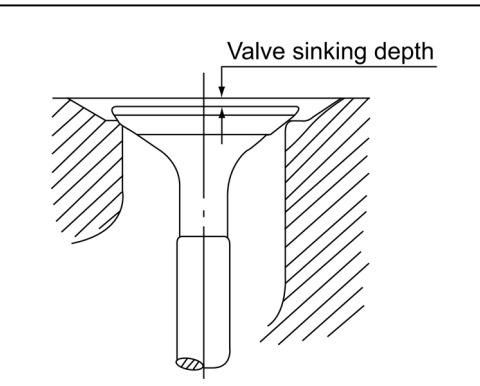
Measure with the valve inserted to the cylinder head.



Valve sink

mm

	Standard	Limit
Intake	0.4∼0.6	0.8
Exhaust	0.4∼0.6	0.8

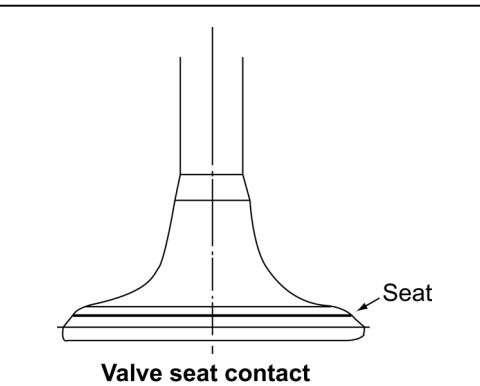


Valve sink depth

(d) Seat contact

Apply a thin coat of minium on the valve seat. Insert the valve in the cylinder and push it against the seat to check seat contact.

Standard: Continuous contact all around

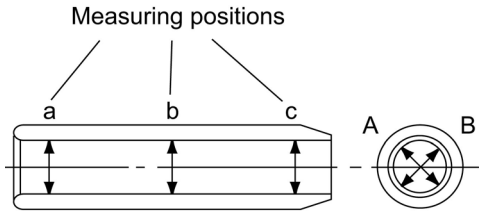


Valve seat contact

(2) Valve guide

Mainly check damage and wear on the inside wall.
Apply supply part code when replacing the part.

Service part code
119717-11800



Valve guide inside diameter

Valve stem clearance

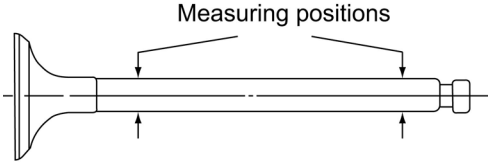
Part name	Place	Standard	Limit
Intake valve	Guide I.D.	6.000∼6.012	6.08
	Stem O.D.	5.960∼5.975	5.90
	Clearance	0.025∼0.052	0.16
Exhaust valve	Guide I.D.	6.000∼6.012	6.08
	Stem O.D.	5.945∼5.960	5.90
	Clearance	0.040∼0.067	0.17

(3) Intake/exhaust valve

Mainly clean and check damage and wear at the valve stem and seat.

(a) Seat contact: See (1)(d) above.

(b) Stem outside diameter: See (2) above.

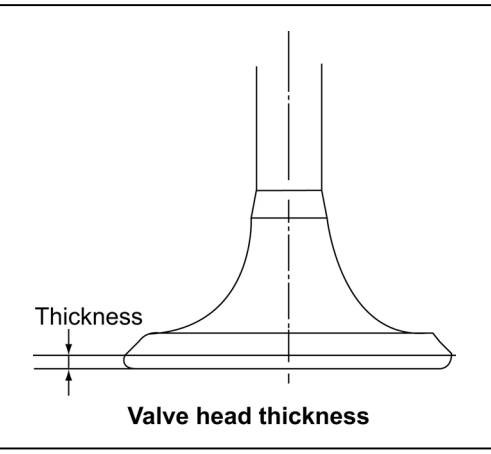


Valve stem outside diameter

(c) Valve head thickness

mm

Part	Standard	Limit
Intake	0.9∼1.1	0.50
Exhaust	1.0∼1.2	0.50



Valve head thickness

(d) Valve stem bend

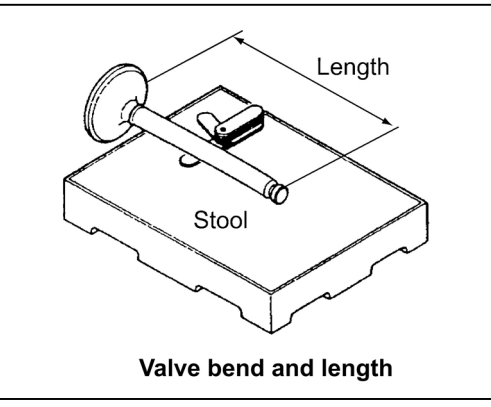
mm

Limit	0.01

(e) Overall length

mm

	Standard	Limit
Intake/ Exhaust	86.8∼87.2	86.6



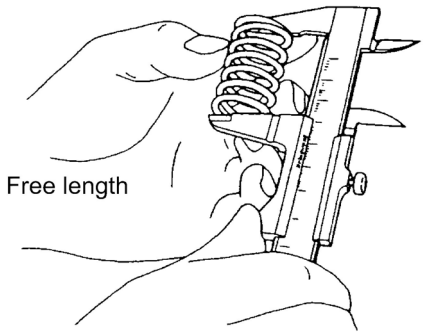
Valve bend and length

(1) Valve spring

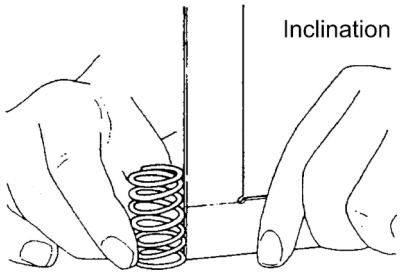
Mainly inspect damage and corrosion.

mm

Free length standard	Inclination limit
37.8	1.3



Valve spring



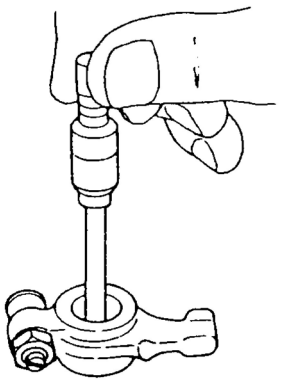
Valve spring

(2) Valve rocker arm

Mainly inspect valve head cap contact surface, inside surface defects and wear.
Slight surface defects shall be corrected with an oilstone.

mm

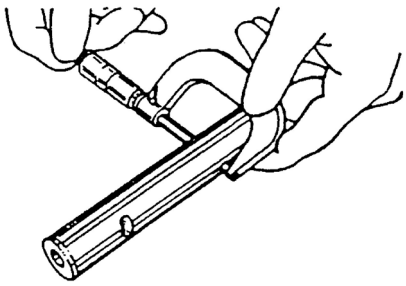
Items	Standard	Limit
Arm hole diameter	12.000～12.020	12.07
Shaft O.D.	11.966～11.984	11.94
Clearance	0.016～0.054	0.13



Rocker arm hole diameter

(3) Rocker arm shaft

Mainly inspect seizure and wear at the surface in sliding contact with the arm. The rocker shaft diameter shall be as specified in (5) above.



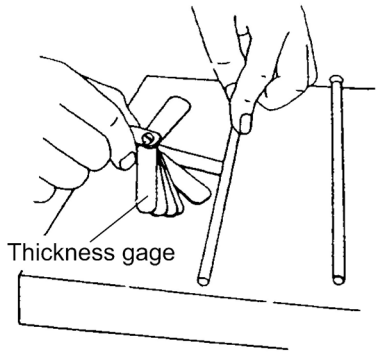
Rocker arm shaft outside diameter

(7) Push rod
Mainly inspect the surface in contact with the tappet and adjusting screw. Slight defects shall be corrected with an oilstone.

Bend limit	0.03mm or less

(8) Valve clearance adjusting screw
Mainly inspect the surface in contact with the push rod.
Slight defects shall be corrected with an oilstone.

(9) Rocker arm spring
Mainly inspect surface defects and corrosion.



Push rod bend

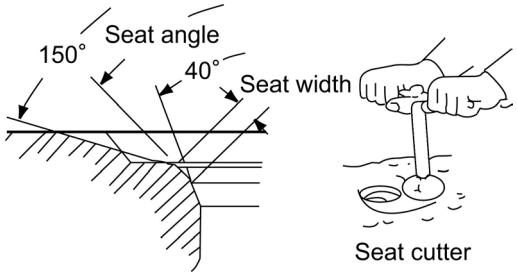
4.2.6 Valve seat correction

[NOTICE]
Always check the oil clearance between the valve and valve guide before correcting the valve seat. If it exceeds the limit, replace the valve or valve guide first to make the clearance satisfy the standard. After correction, wash the valve and the cylinder head sufficiently with diesel fuel oil to remove all grinding powder or compound.

1) If the seat surface is slightly roughened: perform **[A]** and **[B]** below.
[A]: Lap the valve and seat with a mixture of valve compound and lube oil.
[B]: Lap with lube oil only.

2) If the seat is heavily roughened but the width is almost normal, correct with a seat grinder or seat cutter first. Then perform lapping [A] and [B].

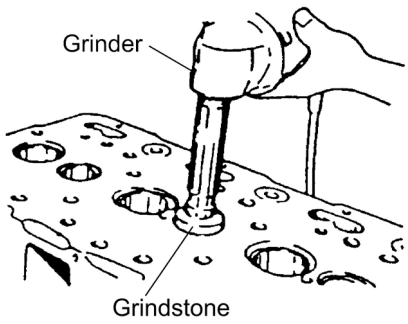
	intake	Exhaust
Seat cutter angle	120	90



Cylinder head correction angle

3) If the seat is heavily roughened and the width is much enlarged, grind the seat inner surface with a seat grinder whose center angle is 40°, then grind the seat outer surface with a grinder whose center angle is 150° to make the seat width match the standard. Then perform seat correction as described in 2), and then carry out lapping **[A]** and **[B]**.

	$\theta 1$	$\theta 2$
Grinding wheel angle	40	150



Seat grinder

4.2.7 Valve guide replacement

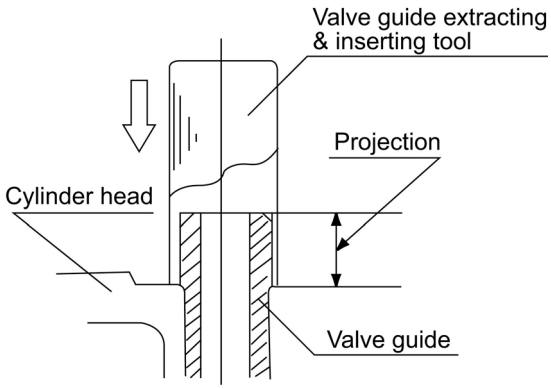
1) Use a valve guide extraction tool(4.1.2(1) No.1 in Chapter 4) and extract the valve guide from the cylinder head.
2) Put liquid nitrogen or ether (or alcohol) with dry ice added in a container and put the valve guide for replacement in it for cooling. Then insert it in with a valve guide inserting tool (Refer to No.2 of 4.1.2(1) in Chapter 4).

⚠ CAUTION

Do not touch the cooled valve guide with bare hands to avoid skin damage.

3) Check the inside diameter and finish to the standard inside diameter as required with a reamer.
4) Check the projection from the cylinder head.

Projection (mm)
9.8～10.0



Valve guide replacement

4.2.8 Valve stem seal replacement

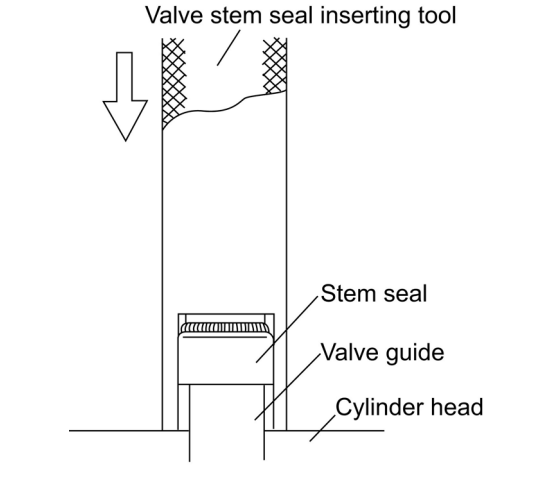
Always use a new valve stem seal after the intake/exhaust valve or valve stem seal is disassembled. Since the one for the exhaust valve is marked with yellow paint, do not confuse the intake and exhaust valves.

[NOTICE]

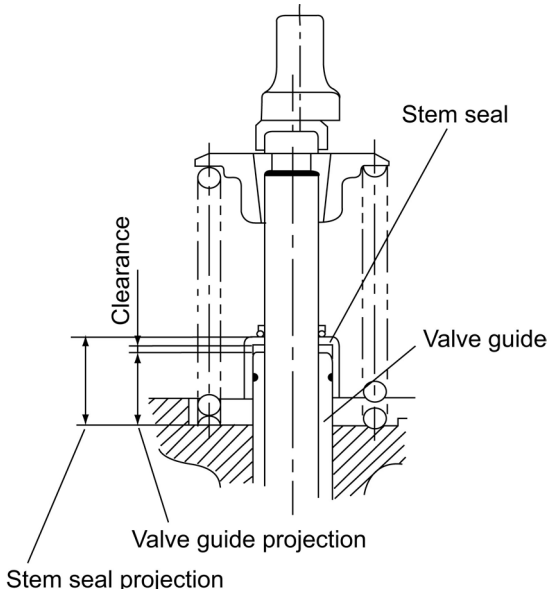
Painting is applied to the springs of both intake/exhaust valve stem seals for the distinction because both parts are different. Be careful because it causes oil down when the attachment of intake/ exhaust is mistaken.
Distinction coloration for the intake is “white” and for the exhaust “black”.

1) Apply lube oil to the lip.
2) Push with the inserting tool (Refer to No.5 of 4.1.2(1) in Chapter 4) for installation.
3) Measure and check the projection of valve stem seal to keep proper clearance between valve guide and stem seal.

Projection (mm)
10.9～11.2

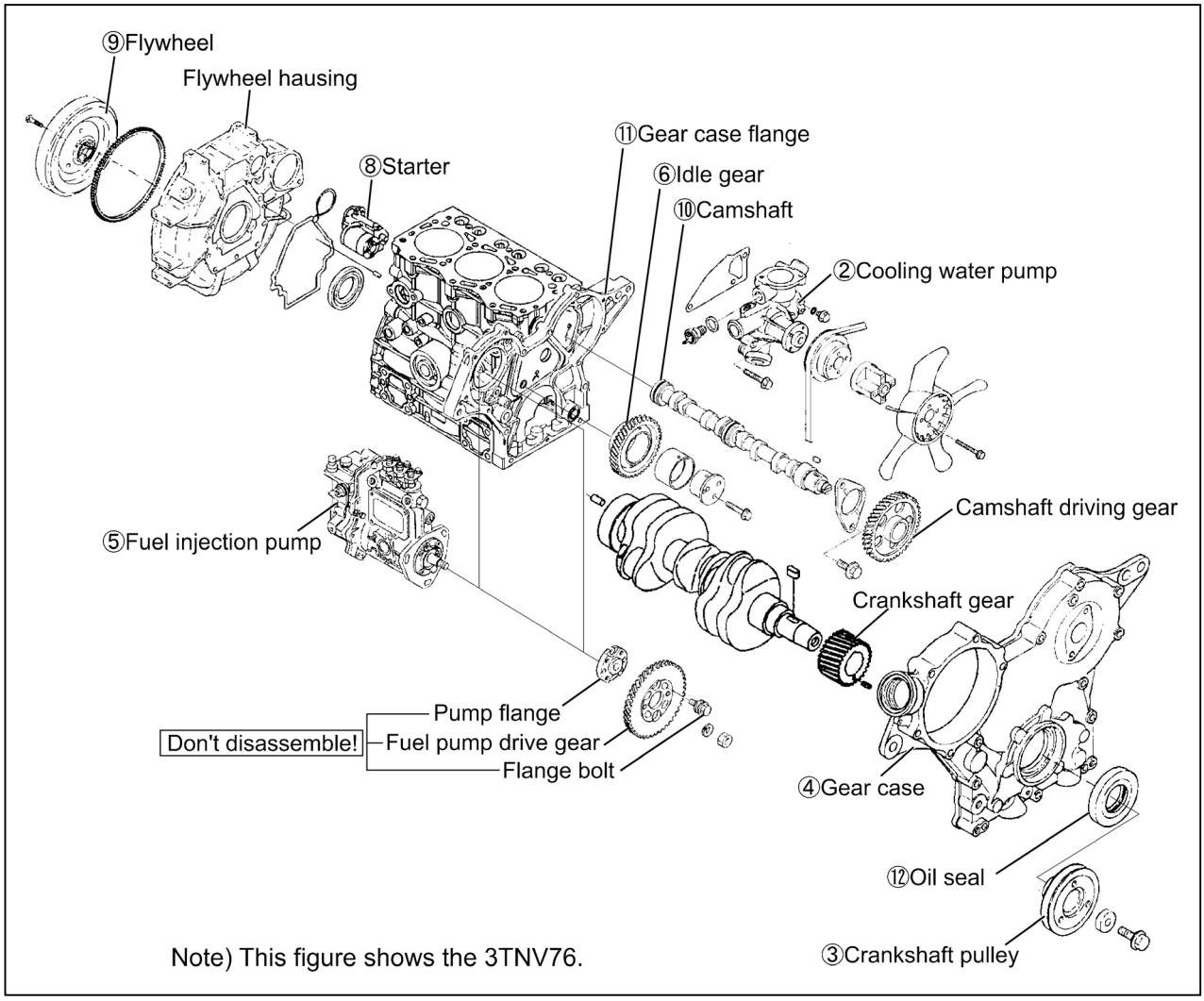


Stem seal insertion



4.3 Gear Train and Camshaft

4.3.1 Components



4.3.2 Disassembly procedure:

Disassemble in the order of the numbers in the illustration.

1) Perform steps 1) to 12) of the cylinder head disassembly procedure.
2) Remove the cooling water pump.
3) Remove the crankshaft pulley. (See **Point 1** of 4.3.4)
4) Remove the gear case. (See **Point 2** of 4.3.4)
5) Remove the fuel injection pump. (See **Point 3** of 4.3.4)
6) Remove the idle gear assy. (See **Point 4** of 4.3.4)
7) Remove the PTO drive gear. (See **Point 5** of 4.3.4)
8) Remove the starting motor.
9) Remove the flywheel. (See **Point 6** of 4.3.4)
10) Remove the camshaft assy. (See **Point 7** of 4.3.4)
11) Remove the gear case flange. (See **Point 8** of 4.3.4)
12) Remove the oil seal from the gear case. (See **4.3.6**)

4.3.3 Reassembly procedure:

Reverse of the disassembly procedure.

4.3.4 Servicing points

Point1

[Disassemble]

- Remove the crankshaft pulley using a gear puller after removing the crankshaft pulley set bolt. When removing the pulley using the gear puller, use a pad and carefully operate so as not to damage the thread. Set the gear puller securely to prevent the pulley from being damaged.

[Reassemble]

- When installing the crankshaft pulley, apply lube oil to the set bolt to tighten and carefully assemble so as not to damage the oil seal.

[NOTICE]

Clean by wiping off any oil on both taper surfaces of crankshaft and pulley using detergent.

N·m(kgf-m)

Material of pulley	Tightening torque
FC250	83.3∼93.3 (8.5∼9.5)
S48C	113∼123 (11.5∼12.5)

Point2

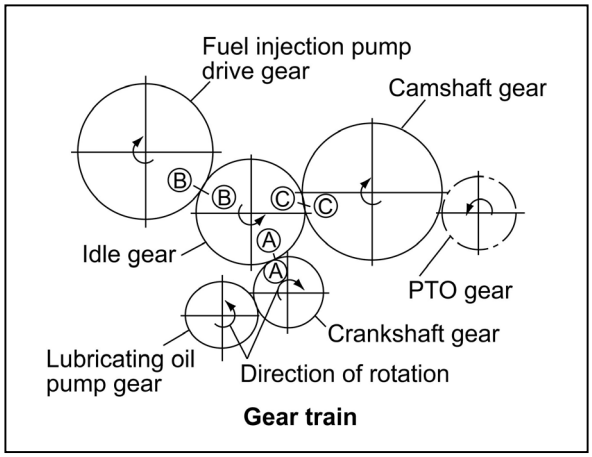
[Reassemble]

- When installing the gear case, do not forget to install the two reinforcing bolts at the center.
- Measure the backlash of each gear.

mm

	Standard	Limit
Crankshaft gear, Camshaft gear, Fuel injection pump gear, Idle gear, PTO gear,	0.06∼0.12	0.14

- Apply sealant after checking that oil doesn't stick on either surface of the cylinder block and the gear case flange and also the gear case flange and the gear case. Install the gear case by correctly positioning the two dowel pins.



Gear train

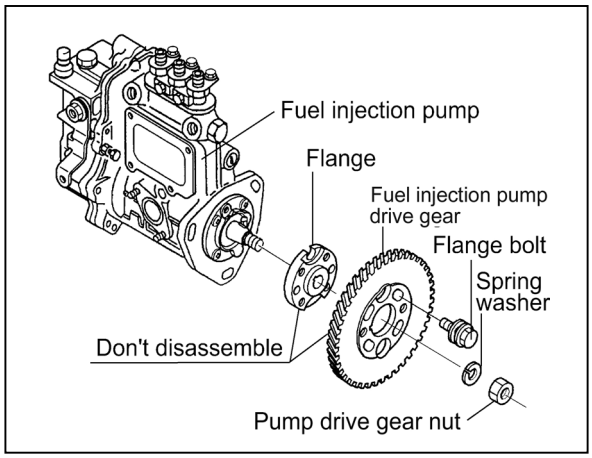
Point3 (Refer to 7.2.5 in chapter 7)

[Disassemble]

- Remove the mounting nut of the fuel injection pump drive gear, remove the gear using the gear puller, and remove the fuel injection pump. When extracting the gear using the gear puller, use a pad at the shaft and carefully operate so as not to damage the thread.

[NOTICE]

Be sure to remove a flange and a drive gear with a pair without loosening flange installation bolts.



[Reassemble]

- Tightening torque for fuel pump drive gear nut (with lube. Oil)

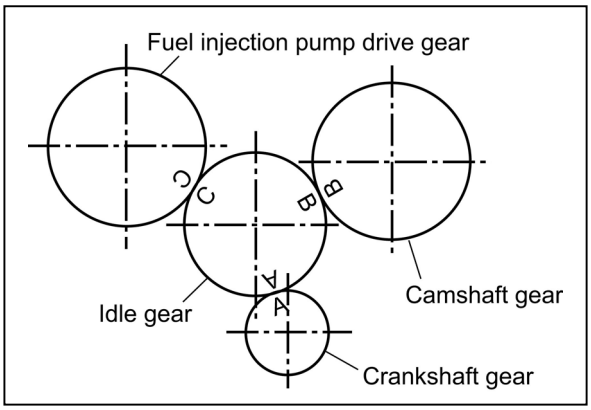
N·m(kgf-m)

Tightening torque
58.8∼68.8 (6∼7)

Point4

[Reassemble]

- Assemble crankshaft gear A, fuel injection pump drive gear B and camshaft gear C at the same time by aligning with idle gear A, B and C marks.
- Install the idle gear shaft with the oil hole facing upward.



Point5

[Reassemble]

- Install the PTO drive gear with its inner spline side facing the flywheel.

Point6

[Disassemble]

- Install a bolt as a handle in the hole at the end face of the flywheel and remove carefully so as not to damage the ring gear.

[Reassemble]

Flywheel mounting bolt: apply lube oil

N·m(kgf-m)

Tightening torque
80.4～86.4 (8.2～8.8)

Point7

[Disassemble]

- Measure the camshaft side gap.

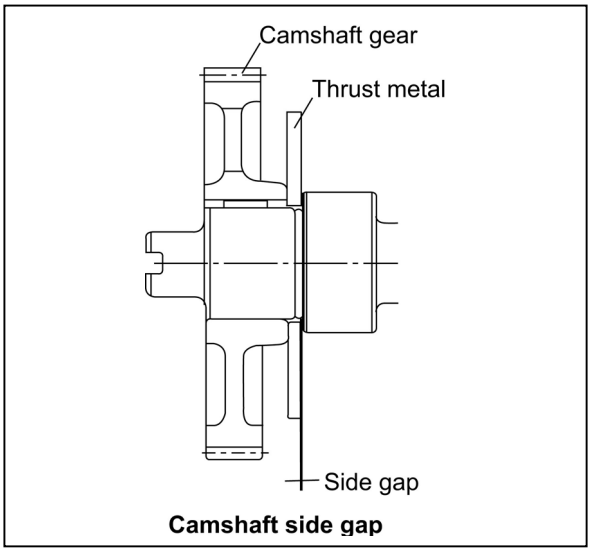
mm

Item	Standard	Limit
Side gap	0.05～0.15	0.25

- If the measured side gap exceeds the limit, replace the thrust metal.

[Disassemble]

- Since the camshaft gear is shrink-fit, heat it to 180℃-200℃ for extraction.
- For camshaft removal, raise the engine with its mounting flange at the bottom. After removing the thrust metal mounting bolt from the camshaft gear hole, extract the camshaft carefully so as not to damage the bearing bushing.



Camshaft side gap

- Rotate the camshaft a few turns before extracting it to prevent the tappet from being caught by the cam.
- After removing the camshaft, set the engine horizontal and fix it on the base.

⚠ CAUTION

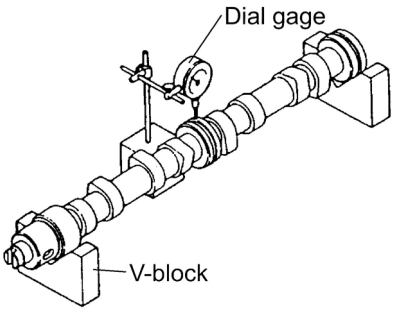
Unforeseen injury may arise due to falling of slipping when raising the engine vertically or returning it to the horizontal position. Proceed carefully so as not to lose balance.

Point8

[Reassemble]

- Do not forget to install the oil pan mounting bolts on the bottom side when installing the gear case.
- Apply sealant (code No.977770-01212) and install the gear case by matching the two dowel pints.

4.3.5 Parts inspection and measurement



Camshaft bend

(1) Camshaft

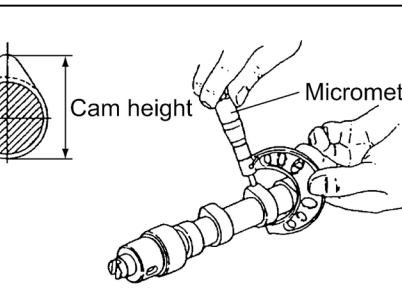
Mainly check the contact between the tappet and cam contact surface, bearing seizure and wear, and gear damage.

(a) Shaft bend measurement

Support the camshaft with V blocks. Rotate the camshaft and measure the distortion at the center of the camshaft and at each journal with a dial gage. Half of the distortion is the bend.

mm

Item	Standard	Limit
Bend	0～0.02	0.05



Cam height

(b) Intake/exhaust cam height measurement

mm

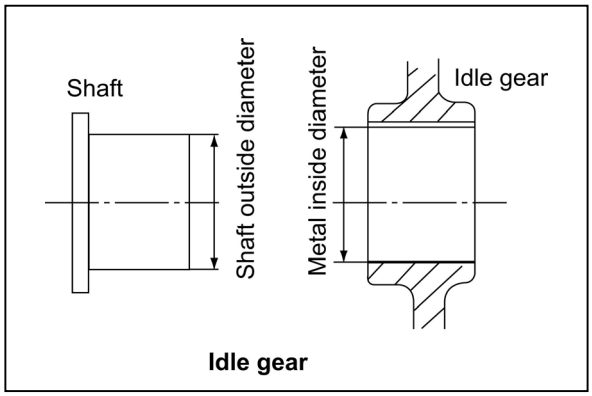
Model	Standard	Limit
2/3TNV70	34.535～34.665	34.29
3TNV76	34.135～34.265	33.89

(c) Camshaft outside diameter and bearing hole diameter measurement Measure the camshaft outside diameter with a micrometer. The oil clearance shall be calculated by subtracting the measured camshaft outside diameter from the camshaft metal inside diameter after insertion to the cylinder measured with a cylinder gage.

mm

Place	Item	Standard	Limit
Gear side	Metal I.D.	40.000～40.075	40.150
	Camshaft O.D.	39.940～39.960	39.905
	Oil clearance	0.040～0.135	0.245
Intermediate position	Metal I.D.	40.000～40.025	40.100
	Camshaft O.D.	39.910～39.935	39.875
	Oil clearance	0.065～0.115	0.225
Wheel side	Metal I.D.	40.000～40.025	40.100
	Camshaft O.D.	39.940～39.960	39.905
	Oil clearance	0.04～0.085	0.195

(2) Idle gear
Mainly check the metal seizure and wear, and gear damage.
Shaft outside diameter and metal inside diameter measurement



Idle gear

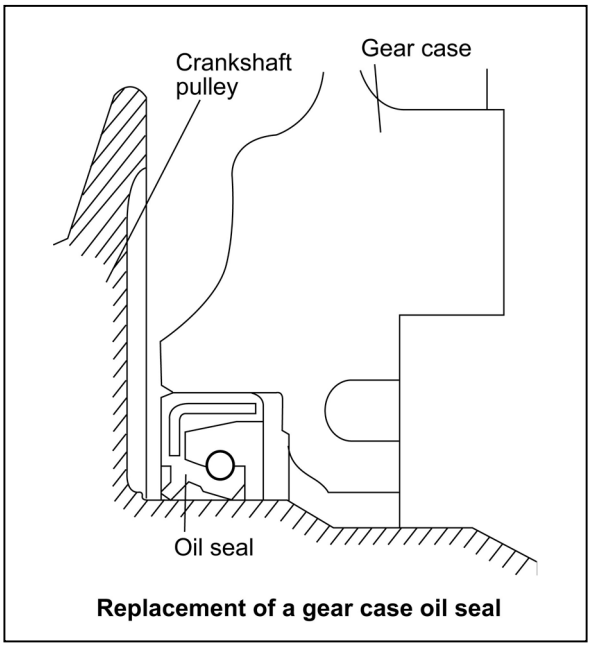
M
mm

Item	Standard	Limit
Shaft outside diameter	44.950∼44.975	44.900
Metal inside diameter	45.000∼45.025	45.075
Clearance	0.025∼0.075	0.175

(3) PTO drive gear
Mainly check sticking of bearings on both sides, gear damage and looseness, and gear shaft damage and wear.

4.3.6 Oil seal replacement

1) Replace the oil seal with a new one when the gear case is disassembled.
   Extract the used oil seal.
2) Insert a new oil seal by using the oil seal insertion tool on the position of the gear case end face. (Refer to the right figure.)
3) Apply lithium grease to the oil seal lips.
4) When wear is found on the oil seal contact part of a crankshaft pulley, replace the pulley with a new one. Carefully install the pulley so as not to damage the oil seal.



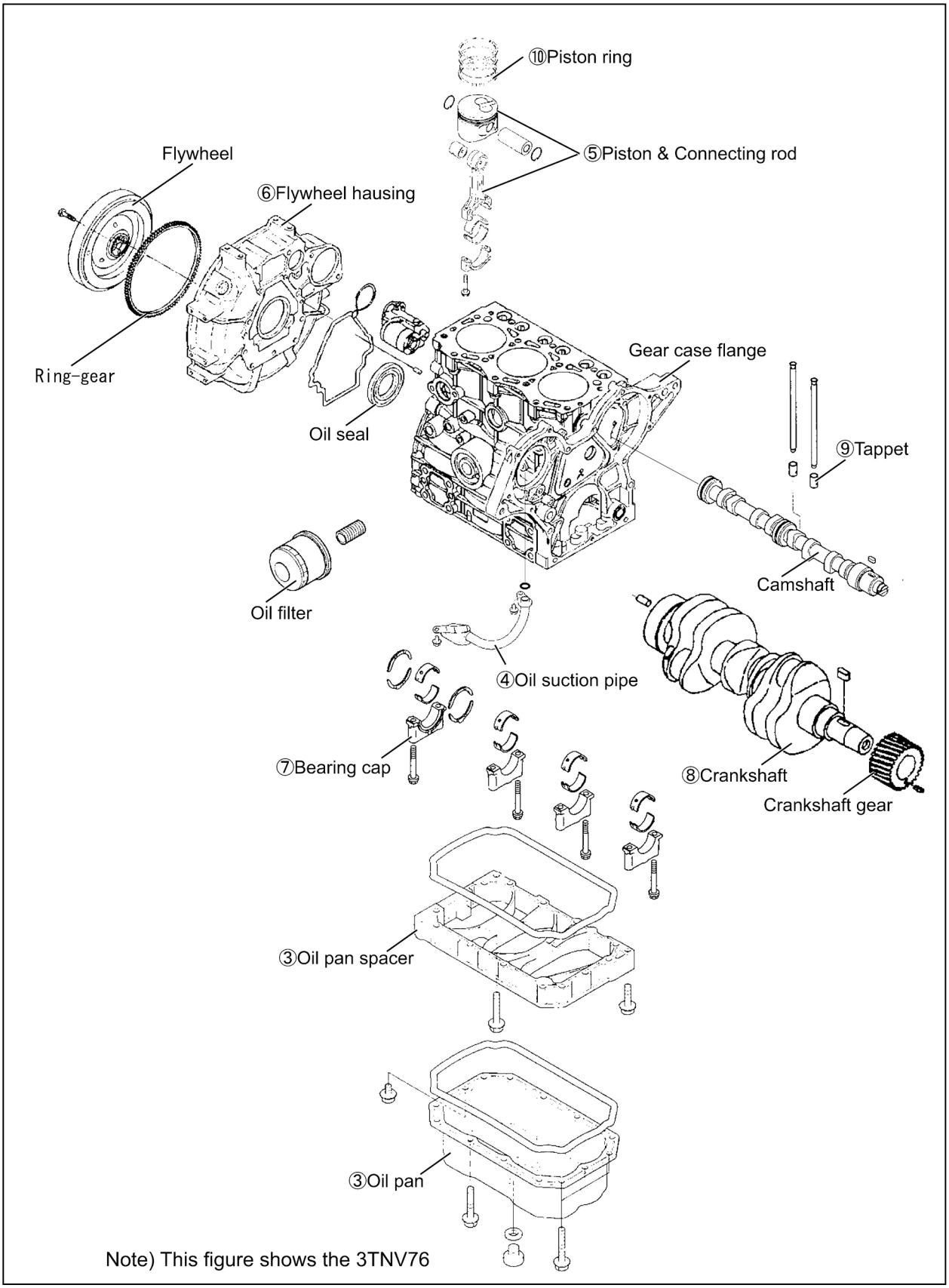
Replacement of a gear case oil seal

4.3.7 Camshaft bushing replacement

Replace the bushing using the special service tool (Refer to No.7 of 4.1.2(1) in Chapter 4).

4.4 Cylinder Block

4.4.1 Components



Note) This figure shows the 3TNV76

4.4.2 Disassembly procedure:

Disassemble in the order of the numbers in the illustration.

1) Perform steps 1) to 15) in the cylinder head disassembly procedure.
2) Perform steps 1) to 12) in the gear train disassembly procedure.
3) Remove the oil pan and the spacer. (See **Point 1** of 4.4.6)
4) Remove the lube oil suction pipe.
5) Remove the piston w/rod. (See **Point 2** of 4.4.6)
6) Remove the mounting flange. (See **Point 3** of 4.4.6)
7) Remove the bearing metal caps. (See **Point 4** of 4.4.6)
8) Remove the crankshaft. (See **Point 5** of 4.4.6)
9) Remove the tappets.
10) Remove the rings from the piston. (See **Point 6** of 4.4.6)
11) Remove the oil seal from the flywheel housing. (See **4.4.8**)

4.4.3 Reassembly procedure:

Reverse of the disassembly procedure.

4.4.4 Servicing points

Point1: Oil pan

[Disassemble]

- Sealant is applied to the oil pan mounting surface on the block. Carefully operate so as not to damage or distort the bonding surface.

[Reassemble]

- Apply sealant (code No.977770-01212) before reassembly.

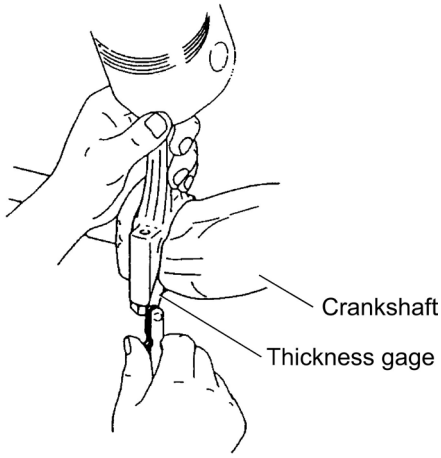
Point2: Piston w/rod

[Disassemble]

- Measure the connecting rod side gap.

mm

Standard
0.20～0.40



Connecting rod side gap

- Carefully remove the carbon deposit on top of the cylinder so as not to damage the inner side of the cylinder.
- Set the piston at the BDC position and remove the connecting rod cap. Then set the piston at the TDC position, and push the connecting rod big end with the wooden shaft of a hammer. Proceed carefully so as not to cause the cylinder block catch the rod big end. Set the rod caps and crankpin metals in their correct combinations.

[Reassemble]

- Apply oil especially carefully to the sliding contact surfaces of the pistons, rods and rings.
- Use the piston insertion tool (see 4.1.2(1) No.9 in Chapter 4) to insert each piston w/rod in the cylinder block and install the bearing metal cap.

Rod bolt tightening torque

N･m(kgf-m)

Standard (apply lube oil)
22.6～27.5 (2.3～2.8)

Point3: flywheel housing

[Disassemble]

Place the engine on a stable base with the cylinder block upper surface facing down, and remove the flywheel housing carefully so as not to damage the combustion surface.

[Reassemble]

Apply sealant (code No.977770-01212) and install flywheel housing by matching the two dowel pins. After assembly, raise the engine with its flywheel housing on the bottom side.

⚠ CAUTION

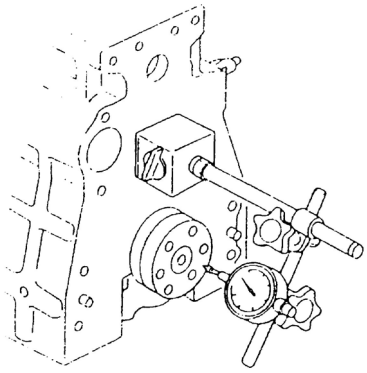
Unforeseen injury may arise due to falling of slipping when raising or reversing the engine. Carefully operate so as not to lose balance.

Point 4: Journal bearing cap

[Disassemble]

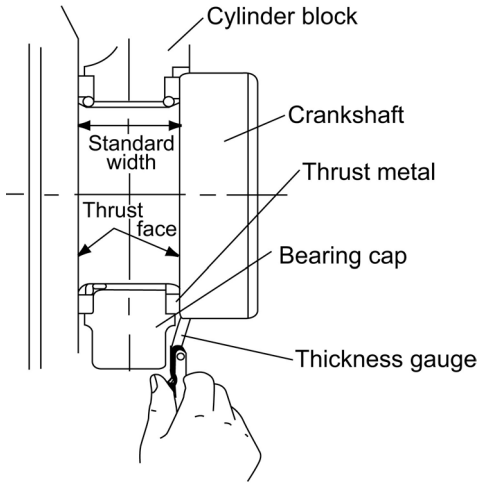
- Before removing the journal bearing, measure the crankshaft side gap. Measure it in either method because there are the next two methods.

1) Install a dial gage on the cylinder block, and move a crankshaft in front and back, and measure the side gap as shown in the right figure.



Side gap measurement 1

2) Put a thickness gauge in the clearance between thrust metal and crankshaft directly, and measure it.



Side gap measurement2

mm

Side gap standard	Limit
0.111～0.250	-

[Reassemble]

- If the side gap exceeds the standard, replace the thrust metal with an oversized one.
- 0.25mm Oversized thrust metal (0.25DS)

mm

Thrust metal assy code	Standard thickness
119810-02940	2.055～2.105

[Disassemble]

- Remove the bearing caps, cap bearings, and thrust metals. Place each thrust metal with identification of the position and direction.
- Carefully install each thrust metal so that the grooved one is positioned away from the cap.

[Reassemble]

- Do not confuse the upper and lower main bearing metals. The upper main bearing metal (block side) has an oil hole, and the lower one does not. The “wheel and arrow” marks on the cap shall face the flywheel.

Main bearing cap bolt tightening torque (apply lube oil)

N･m(kgf-m)

Standard
75.5～81.5 (7.7～8.3)

Point5: Crankshaft

[Disassemble]

- Remove the crankshaft. Remove each main bearing metal upper (block side) and pair it with the metal cap side lower metal.

⚠ CAUTION

Carefully prevent the bearing from being damaged or finger injury when removing the crankshaft because it is heavy.

Point 6: Piston pin and rings

[Disassemble]

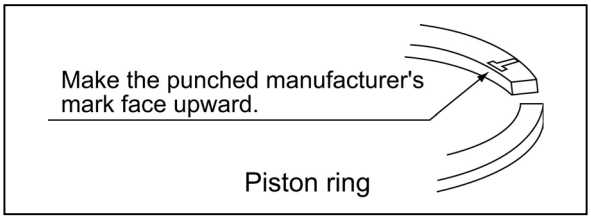
- Using the piston ring replacer (see 4.1.2(1) No.10 in Chapter 4), remove the piston rings.
- Remove the circlip and remove the piston pin by pushing it out.

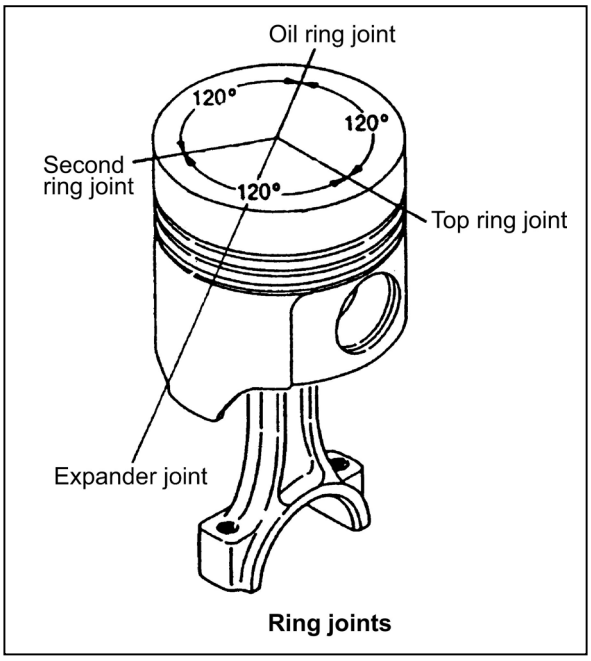
[Reassemble]

- Install each piston ring on the piston, with the punched manufacturer's mark facing upward.

[Reassemble]

- The piston ring joints shall be staggered at by 120℃ intervals. Do not position the top ring joint vertical to the piston pin. The coil expander joint shall be opposite to the oil ring joint.





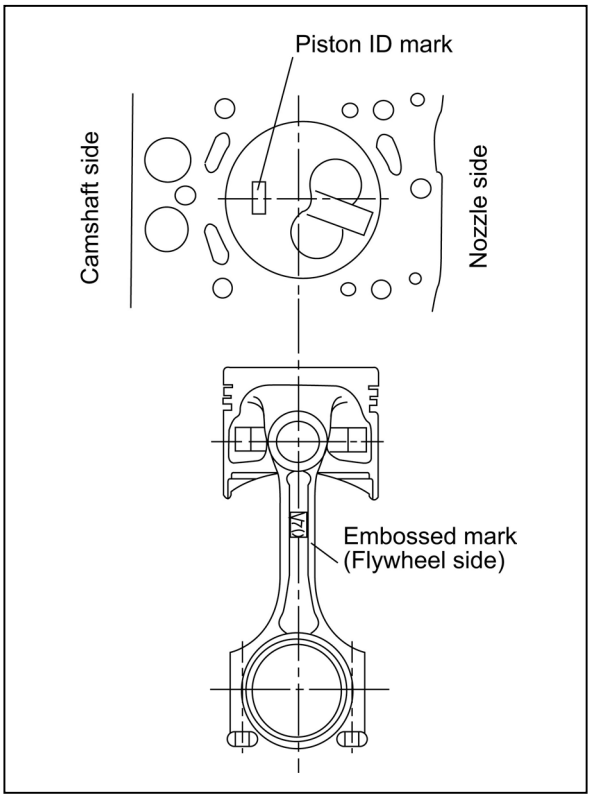
Ring joints

[Reassemble]

- When installing the piston pin to the rod and piston, the punched match mark on the big end of the connecting rod shall be opposite to the size mark on the piston top.

[Reassemble]

- Install the piston in the cylinder block. The embossed mark on the connecting rod shall be on the flywheel side.



4.4.5 Parts inspection and measurement

(1) Cylinder block

Especially clean head surface, cylinder bores and oil holes, and check the below items after removing any carbon deposit and bonding agent.

(a) Appearance inspection

Check if there is any discoloration or crack. If crack is suspected, perform color check. Sufficiently clean the oil holes and check they are not clogged.

(b) Cylinder bore and distortion

Measure at 20 mm below the crest of the liner, at 20 mm from the bottom end and at the center in two directions A and B as shown in the below figure.

Roundness:

Roundness is found as follows though it is the simple method. Measure cylinder diameters of the A direction and the B direction on each section of a, b and c.

Roundness is the maximum value among those difference values.

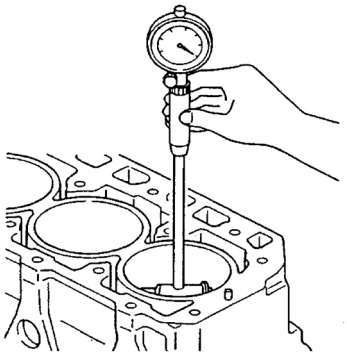
Cylindricity:

Cylindricity is found as follows though it is the simple method.

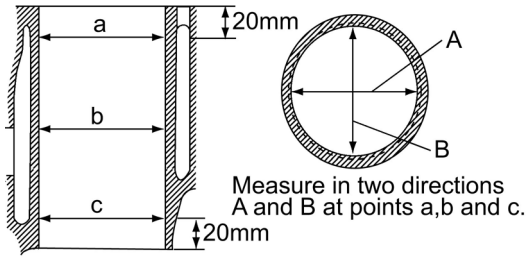
Measure cylinder diameters of a, b and c sections in the A direction, and calculate the difference in maximum value and minimum value of the measured diameters.

In the same way measure and calculate the difference in the B direction.

Cylindricity is the maximum value between those difference values.



Cylinder bore



Cylinder bore measurement positions

mm

Item		Model	Standard (M size)	Limit
Cylinder inside diameter		2/3TNV70	70.000～70.030	70.200
		3TNV76	76.000～76.030	76.200
Cylinder bore	Roundness	all TNV	0.01 or less	0.03
	Cylindricity			

(c) If the limit is exceeded or any surface defect is found, repair by boring and honing. Use an oversized piston (and new piston rings) as required.

Oversized piston (0.25 mm) mm

Model	Code No.	Standard
2/3TNV70		ϕ70.250
3TNV76	119717-22090	ϕ76.250

Piston ring for oversized (0.25mm)

Model	Piston ring code No. (Assy)
2/3TNV70	
3TNV76	119717-22550

Cylinder boring dimension mm

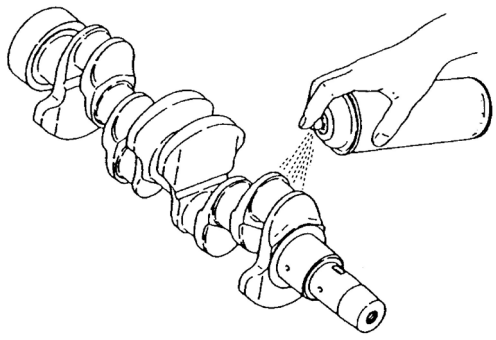
Model	Boring dimension
2/3TNV70	ϕ70.250-70.280
3TNV76	ϕ76.250-76.280

(2) Crankshaft

Mainly check seizure and wear of the crankpins and journals. Since the crankshaft gear is shrink-fitted, heat to 180 to 200℃ when extraction is necessary.

(a) Shaft portion color check

After washing the crankshaft, inspect it by means of color check or a magnaflux inspector. Replace it if cracked or heavily damaged. Slight defects shall be corrected by grinding.

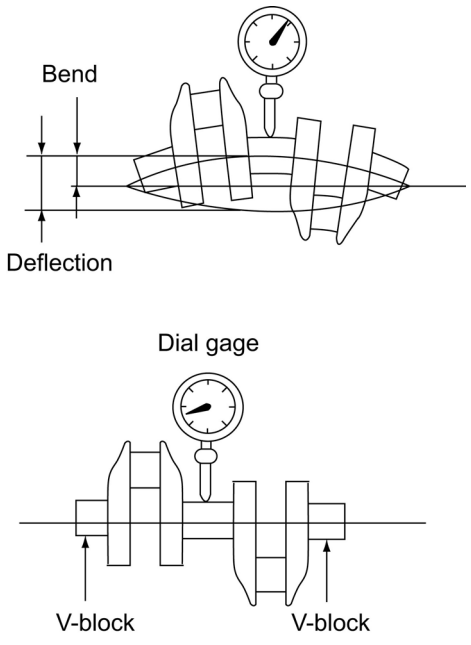


Inspection by color check

(b) Crankshaft bend

Support the crankshaft journals at both ends with V-blocks. Use a dial gage and measure the run-out at the center journal while rotating the shaft to inspect the bend. The bend is half of the run-out value.

Limit	0.01mm or less



Crankshaft bend measurement

(c) Crankpin and journal measurement
Measure the outside diameter, roundness and taper at each crankpin and journal.
Correct by grinding if unevenly wear, roundness exceeding the limit or insufficient outside diameter is found. Replace if the defect is excessive.

Crankpin

If a clearance is necessary, measure the inside diameter by following (5) d) " Rod big end measurement ", and calculate it.

mm

Item	Standard	Limit
Pin outside diameter	41.952～41.962	41.902
Oil clearance	0.020～0.050	0.110
Roundness	0.01 or less	0.02

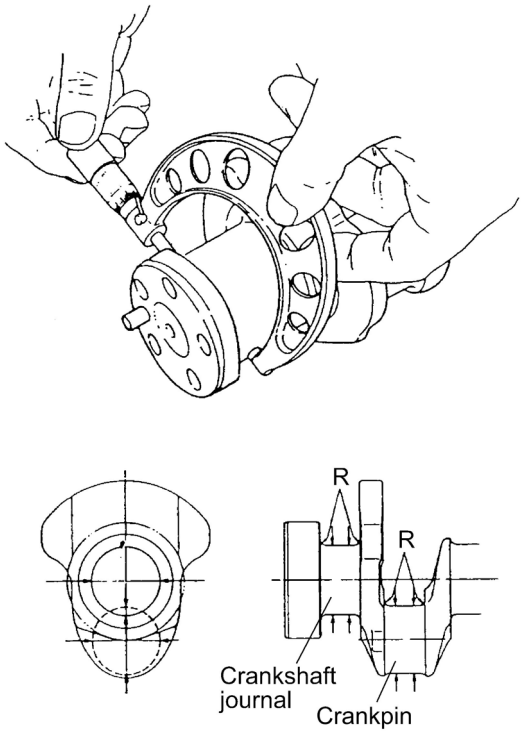
If the oil clearance exceeds the limit, use an undersized bearing.

Undersized bearing (0.25 mm)

Code No.(assy)
119717-23610

Pin machining dimension mm

Pin machining dimension
ϕ41.702～41.712



Measuring position of the crankpin and crank journal

Crank journal

mm

Item	Standard	Limit
Journal O.D.	46.952～46.962	46.902
Oil clearance	0.020～0.050	0.120
Roundness	0.01 or less	0.02

If the clearance limit is exceeded, use an undersized bearing and machine the crank journal into the value of the below table.

Undersized bearing (0.25mm)

Code No. (assy)
119717-02870

Crankshaft Journal machining dimension

mm

Journal machining dimension
ϕ46.702～46.712

Dimension R and finishing precision of crankshaft journal and pin

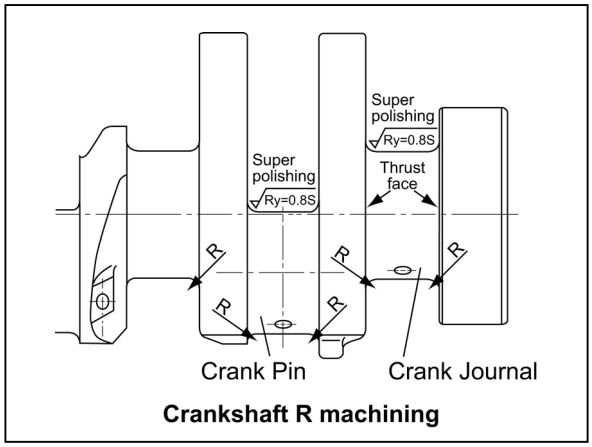
As for grinding processing of journal and pin, machine it by using the grinding wheel of the dimension R of below table.

mm

Finishing precision standard of dimension R
$3.5\,^{+0.3}_{0}$

Surface finishing precision standard on journal and pin:
Ry=0.8S super polishing

Surface finishing precision standard on the thrust side of crankshaft arm: 1.6



Crankshaft R machining

[NOTICE]

1) If the oil clearance is excessive though the thickness of the journal and crankpin metals are normal or if partial uneven wear is observed, re-grind the crankshaft and use an undersized metals.
2) If rust or surface roughening exists on the rear side of the metals, coat it with blue or minimum. Then assemble the crankpin metal to the connecting rod, and tighten the rod bolt to the specified torque to check the metal for contact. If the contact surface occupies 75% or more, the metal is normal. If the contact surface is insufficient, the metal interference is insufficient. Replace the metal with a new standard one.

(3) Thrust metal inspection

(a) Inspect any damage or wear.

(b) Measure side gap and thrust metal thickness

Side gap and thrust metal thickness mm

Side gap		Thrust metal thickness	
Standard	Limit	Standard	Limit
0.111～0.250	-	1.930～1.980	1.850

If the side gap is exceeded, use an oversized thrust metal.

Oversized metal(0.25mm) mm

Code No. (assy)	Standard thickness
119810-02940	2.055～2.105

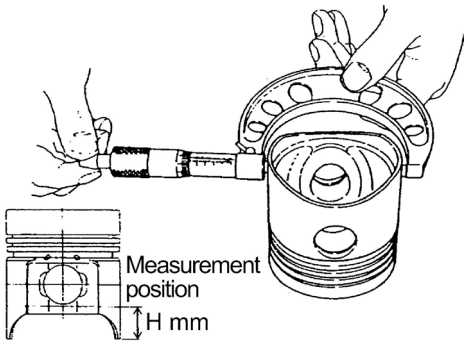
(4) Piston

Especially clean the combustion surface, circumference, ring grooves and piston pin bosses, and check after removing any carbon deposit. Any burr at a ring groove or snap ring groove shall be removed. If crack is suspected, inspect by color check.

(a) Piston outside diameter measurement

Measure the long diameter at H mm from the bottom end of the piston of the oval hole in the vertical direction to the piston pin hole.

The clearance between a piston and a cylinder is calculated by using a measured piston outside diameter and a cylinder inside diameter measured according to 4.4.5(1)(b).



Piston outside diameter

mm

Model	Piston outside diameter	Limit	Clearance between piston and cylinder	Measurement position (H)
2/3TNV70	69.960～69.990	69.915	0.030～0.050	22～25
3TNV76	75.955～75.985	75.910	0.035～0.055	22～25

If the piston outside diameter exceeds the limit, replace the piston with new one.
If necessary, use an oversized piston. (Refer to the tables of oversized pistons, oversized piston rings and cylinder boring dimension in 4.4.5(1)(c).)

Selective pairing of cylinder and piston

Piston must be paired with cylinder according to the below table. The size mark of a piston is shown on the top surface of the piston and the size mark of a cylinder block is shown on the non-operating side of the cylinder block. The service parts of pistons are provided.

(mm)

			Piston outside diameter. D2			
	Tolerance		+0.015 max. +0.005 min.	below+0.005 0 min.	below 0 -0.005 min.	below -0.005 -0.015 min.
		Size mark	L	ML	MS	S
Cylinder inside diameter D1	+0.030 max. +0.020 min.	L	○	○	×	×
	below +0.020 +0.010 min.	M	×	○	○	×
	below +0.010 0 min.	S	×	×	○	○

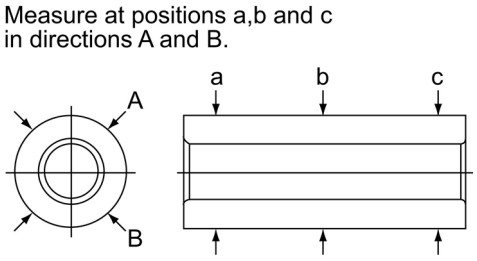
(mm)

Model	Cylinder inside diameter D1	Piston outside diameter. D2
2/3TNV70	70	69.975
3TNV76	76	75.970

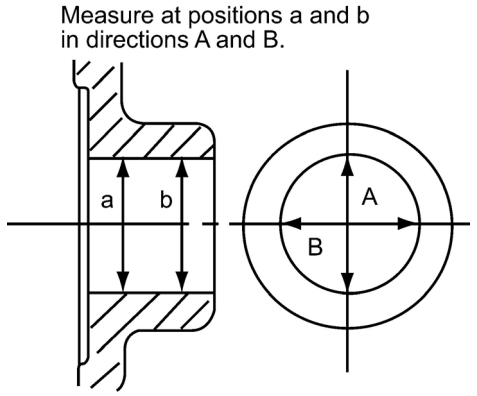
(b) Piston pin and piston pin hole measurement
Measure the outside diameter of piston pin and the inside diameter of piston pin hole. Calculate the clearance between piston pin and piston pin hole. If any data exceeds the limit, replace the part with a new one.

mm

Item	Standard	Limit
Pin I.D.	22.000～22.009	22.039
Pin O.D.	21.995～22.000	21.965
Clearance	0.000～0.014	0.074



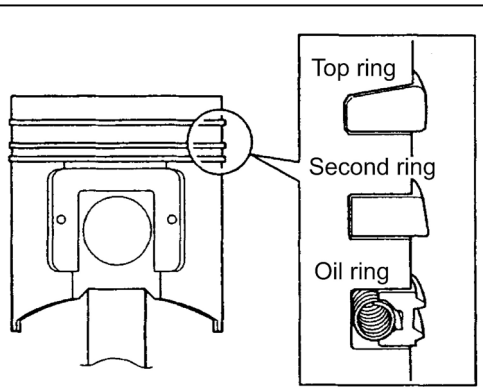
Piston pin outside diameter



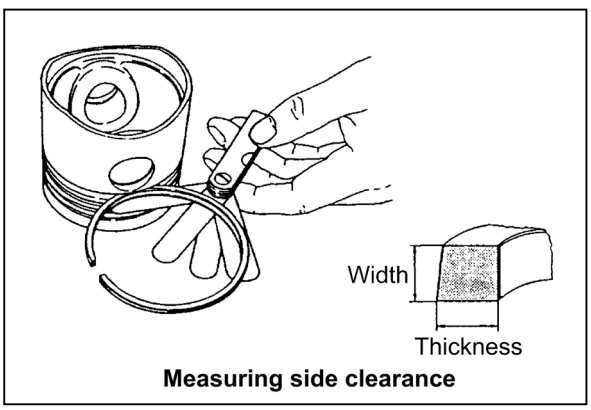
Piston pin hole

(c) Piston ring, ring groove and end clearance measurement

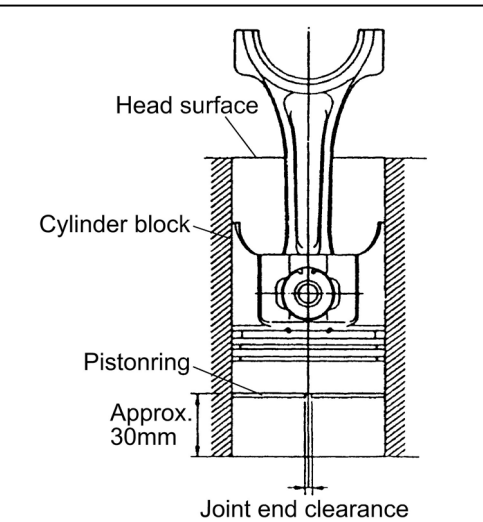
- Except for the top ring, to measure the piston ring groove width, first measure the width of the piston ring. Then insert the piston ring into the ring. Then insert the piston ring into the ring groove. Insert a thickness gage in between the piston ring and groove to measure the gap between them. Obtain the ring groove width by adding ring width to the measured side clearance.
- To measure the end clearance, push the piston ring into the sleeve using the piston head, insert a thickness gage in end clearance to measure. The ring shall be pushed in to approx. 30 mm above the bottom end of the cylinder. For the top ring, measure only the piston ring joint end clearance in normal state.



Ring components



Measuring side clearance



Ring joint end clearance measurement

Piston ring dimension mm

Model	Part	Item	Standard	Limit
2/3TNV70	Top ring	Ring groove width	1.550～1.570	-
		Ring width	1.470～1.490	1.450
		Side clearance	0.060～0.100	-
		End clearance	0.15～0.30	0.39
	Second ring	Ring groove width	1.540～1.560	1.660
		Ring width	1.470～1.490	1.450
		Side clearance	0.050～0.090	0.210
		End clearance	0.18～0.33	0.42
	Oil ring	Ring groove width	3.010～3.030	3.130
		Ring width	2.970～2.990	2.950
		Side clearance	0.020～0.060	0.180
		End clearance	0.20～0.45	0.54
3TNV76	Top ring	Ring groove width	1.550～1.570	-
		Ring width	1.470～1.490	1.450
		Side clearance	0.060～0.100	-
		End clearance	0.15～0.30	0.390
	Second ring	Ring groove width	1.580～1.595	1.695
		Ring width	1.430～1.450	1.410
		Side clearance	0.013～0.165	0.285
		End clearance	0.18～0.33	0.420
	Oil ring	Ring groove width	3.010～3.025	3.125
		Ring width	2.970～2.990	2.950
		Side clearance	0.020～0.055	0.175
		End clearance	0.20～-0.45	0.540

(5) Connecting rod

(a) Appearance inspection

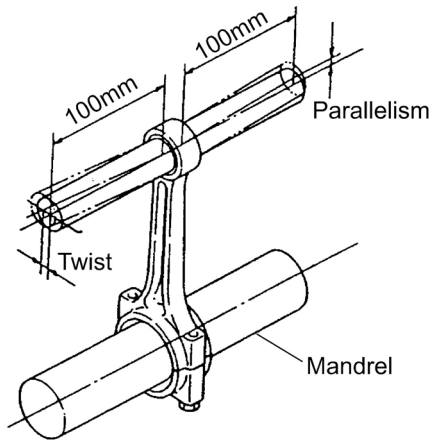
Inspect the portion near the boundary of the chamfered portion and I-beam section of the big and small ends of the connecting rod as well as the portion near the oil hole of the bushing at the small end for cracks, deformation, and discoloration.

(b) Twist and parallelism measurement

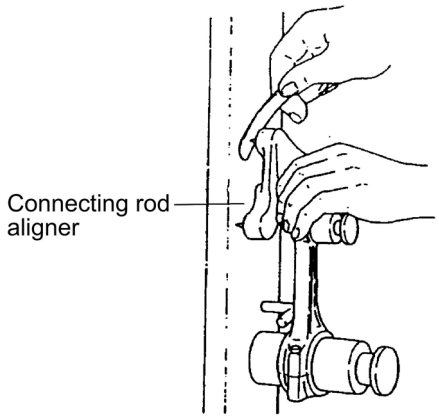
Use a connecting rod aligner and measure the twist and bend.

mm

Item	Standard dimension	Limit dimension
Twist and parallelism	0.03 or less per 100mm	0.08



Twist and parallelism measurement



Twist measurement using a connecting rod aligner

(c) Rod small end measurement

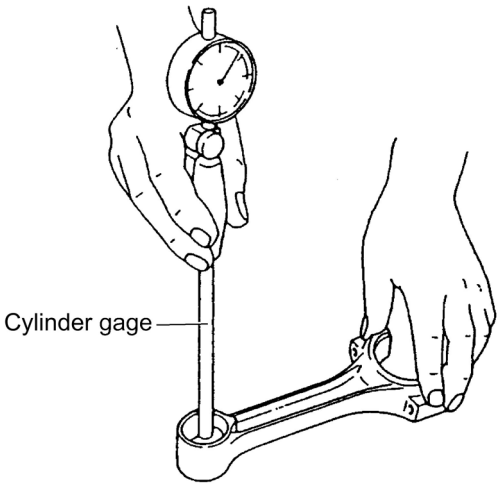
Measure the pin outside diameter according to 4.4.5.(4)(b) described above.

mm

Item	Standard	Limit
Piston pin metal I.D.	22.025～22.038	22.068
Pin O.D.	21.991～22.000	21.963
Clearance	0.025～0.047	0.105

If the metal is to be replaced because the oil clearance exceeds the limit, use spare part.

Service part code
119717-23910



Connecting rod small end

(d) Rod big end measurement
Measure the crankpin outside diameter.
The oil clearance is calculated as the difference in the crankpin outside diameter and the crank pin metal inside diameter (refer to 4.4.5.(2)(c)).
Replace the crankpin metal if a clearance becomes close to the limit value in the table below.
If wear and unevenly wear on the crankpin is found, correct by grinding the crankpin and apply the undersized bushing (refer to 4.4.5.(2)(c))

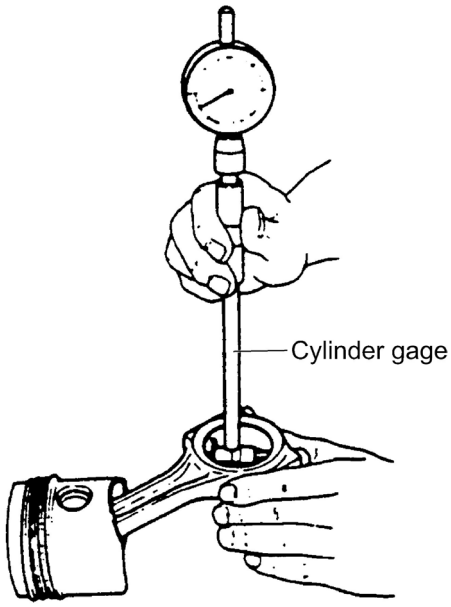
[NOTICE]
When measuring the inside diameter of the rod big end, install the bushing in the rod big end not to mistake top and bottom of the crankpin metal and fasten the rod bolts by the standard torque shown in the table.

Tightening torque of rod bolt N·m(kgf-m)

Tightening torque	Lube oil application (threaded portion, and bearing seat surface)
22.6～27.5(2.3～2.8)	Lube. oil applied

Standard of rod big end mm

Item	Standard	Limit
Crankpin O.D.	41.952～41.962	41.900
Metal I.D.	41.982～42.002	-
Metal thickness	1.503～1.509	-
Clearance	0.020～0.058	0.120



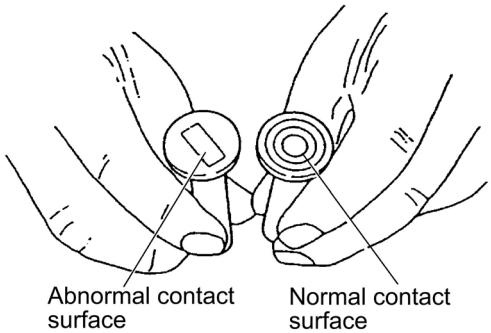
Crankpin metal I.D. measurement

(6) Tappet
Mainly check the tappet contact surface with the cam and push rod. Slight surface defects shall be corrected with an oilstone.

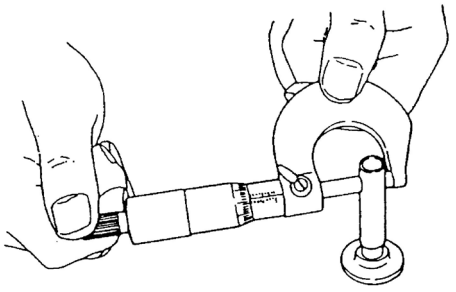
Tappet stem outside diameter measurement
The outside diameter of the tappet stem is measured by a micrometer.
The clearance is calculated from the measured tappet hole and the measured stem diameter.

mm

Item	Standard	Limit
Tappet hole I.D.	21.000～21.021	21.041
Stem O.D.	20.927～20.960	20.907
Clearance	0.040～0.094	0.134



Tappet


Tappet stem O.D. measurement

4.4.6 Cylinder bore correction

(a) Slight uneven worn, flawed, etc. shall be corrected by honing only. If the cylinder is unevenly worn partially, flawed or otherwise damaged and cannot be repaired simply by honing, rebore the cylinder first and then hone. See 4.4.5.(1)(c) for the boring dimension.

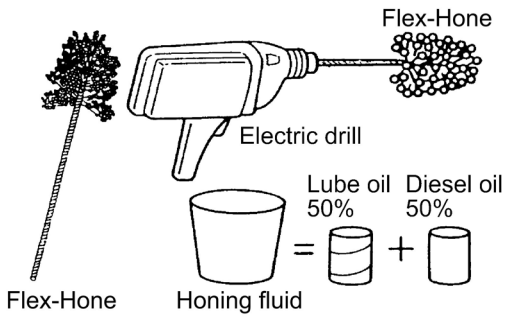
(b) Items to be prepared for honing

- Flex-Hone (see No.8 of 4.1.2 in Chapter 4)
- Electric drill
- Honing fluid (50:50 mixture of lube oil and diesel oil)

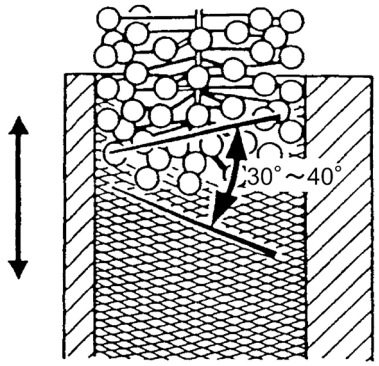
(c) Apply the honing fluid to the Flex-Hone and turn the electric drill at 300 to 1200 min^{-1}. Then insert the Flex-Hone into the cylinder bore while turning it, and move it up and down for about 30 sec. to obtain a honing mark with a cross hatch angle of 30 to 40° .

[NOTICE]

1) Avoid faster revolution than 1200 min^{-1} since it may cause breakdown.
2) Do not insert or extract the Flex-Hone in stopped state because the cylinder will be damaged.



Items to be prepared for honing



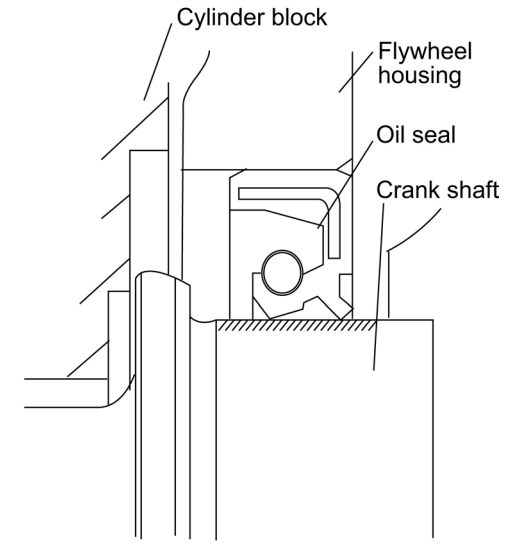
Honing cross hatch

4.4.7 Piston pin metal replacement

Replace metal by using the special service tool (see No.3 of 4.1.2 in Chapter 4).

4.4.8 Oil seal replacement (Flywheel housing side)

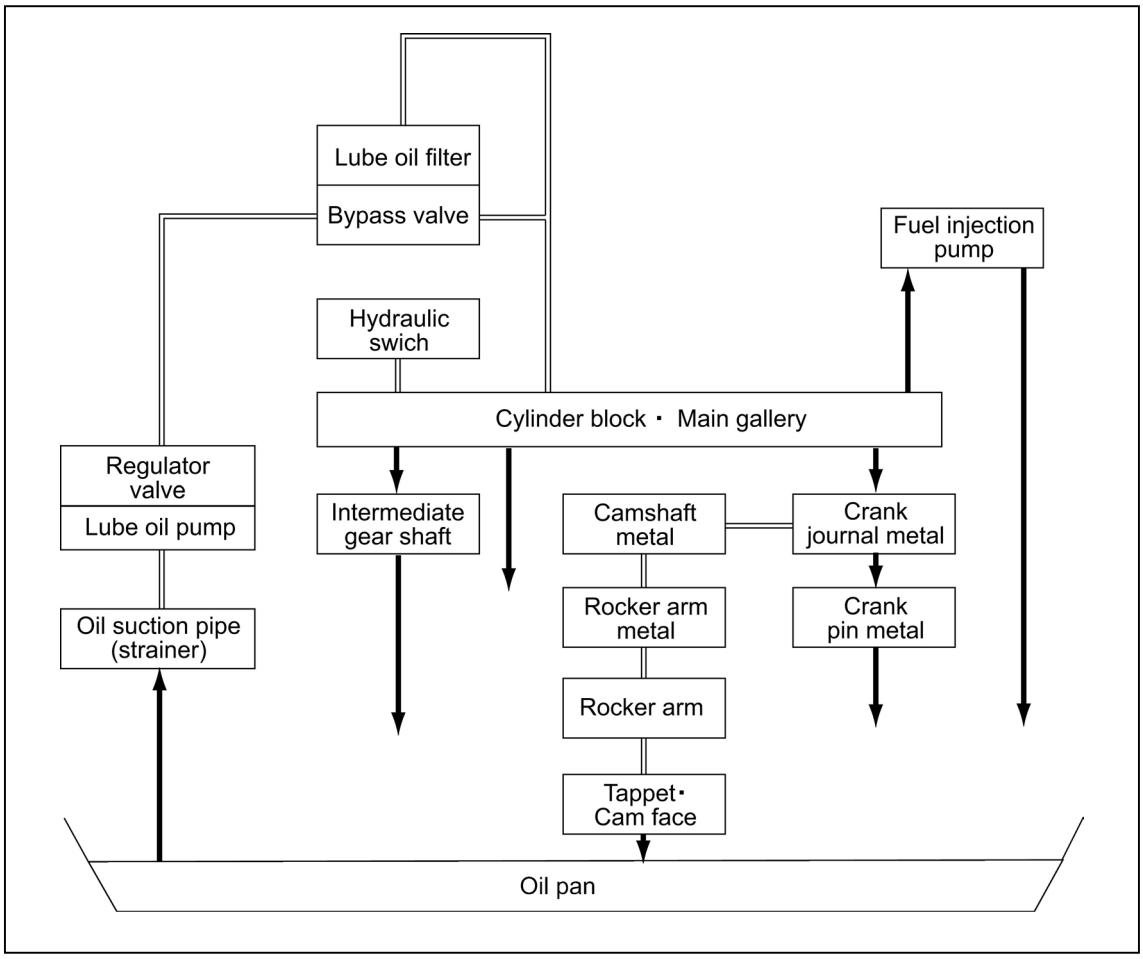
1) Replace an oil seal with new one when a flywheel housing is removed. Extract the used oil seal.
2) Insert a new oil seal by using the oil seal insertion tool on the position of the flywheel housing end face. (Refer to the right figure.)
3) Apply lithium grease on the lip.
4) Install the flywheel housing on the cylinder block with being careful not to damage the oil seal.



Replacement of a flywheel housing oil seal

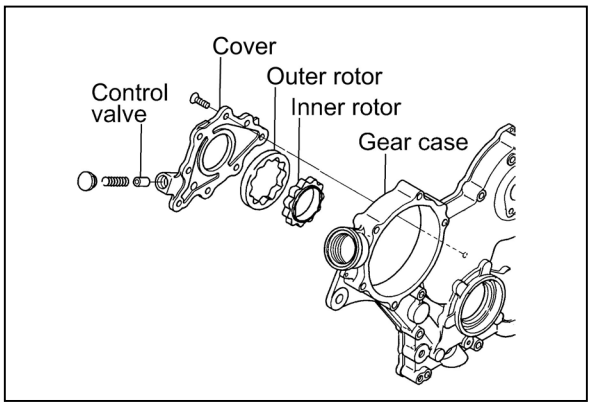
5. LUBRICATION SYSTEM

5.1 Lubrication System Diagram



5.2 Trochoid Pump Components

Trochoid pump



5.3 Disassembly(Reverse the below procedure for reassembly)

1) Loosen the belt, and remove the radiator pulley, fan and V-belt. (See 4.2.2. 2) in Chapter 4.)
2) Remove the crankshaft pulley. (See 4.3.2. 3) in Chapter 4.)
3) Remove the gear case cover. (See 4.3.2. 4) in Chapter 4.)
4) Remove the lube oil pump cover from the gear case cover. (**Point 1** in 5.4)
5) Remove the pressure regulating valve from the lube oil pump cover. (**Point 2** in 5.4)

5.4 Servicing Points

Point 1

[Disassemble]

- Check if the pump rotates smoothly and see that there is no play between the shaft and gear, and inner rotor.

[Reassemble]

- Rotor (outer/inner) insertion part is to apply lube oil.
- For installation on the gear case cover, tighten the lube oil pump cover by the standard torque.

Nm(kgf･m)

Tightening torque	Lube oil application (threaded portion, and bearing seat surface)
5.9～7.9 (0.6～0.8)	Lube. oil applied

- When replacing the lube oil pump, replace the whole assy including the outer/inner rotor.

[NOTICE]

Always check if the pump rotates smoothly after installation on the gear case cover.
Running the engine when the pump rotation is heavy may cause the pump to be burnt.

Point 2

[Disassemble-Reassemble]

- Only wash the pressure regulating valve. Disassembly is unnecessary unless any abnormality in operation is detected.

5.5 Parts Inspection and Measurement

5.5.1 Trochoid pump inspection and measurement

(1) Outside diameter clearance and side clearance of outer rotor

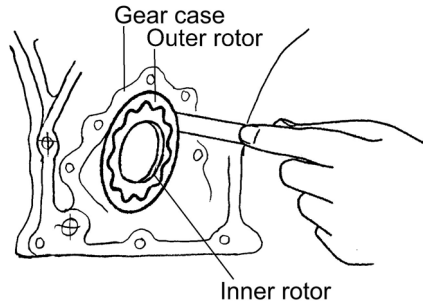
Insert a gap gauge between the outer rotor and the gear case cover, and measure outside diameter gap. Put a ruler on the end face of the gear case cover, and insert a gap gauge between rotor, and measure a side gap.

Outside clearance mm

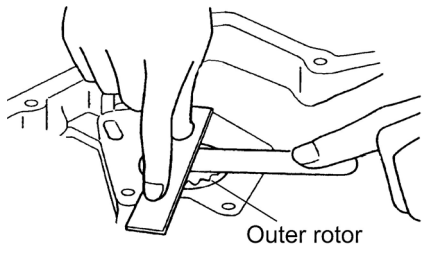
Standard	Limit
0.12～0.21	0.30

Side clearance mm

Standard	Limit
0.02～0.07	0.12



Outer diameter clearance



Side clearance

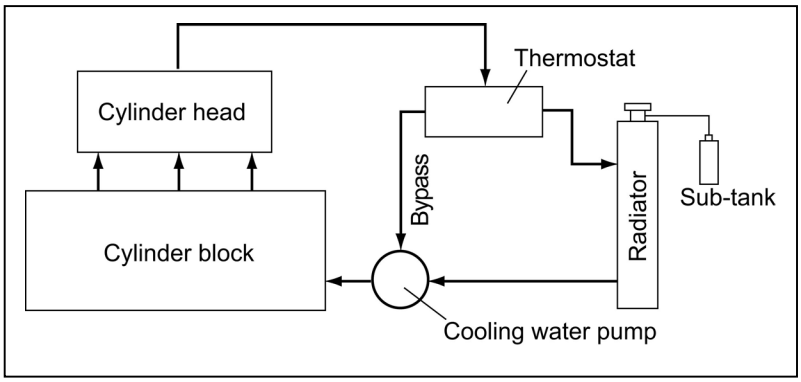
(2) Outside diameter clearance of inner rotor centering location part

Measure the outside diameter of inner rotor centering location part and the hole diameter of gear case cover. Calculate the clearance from that difference.

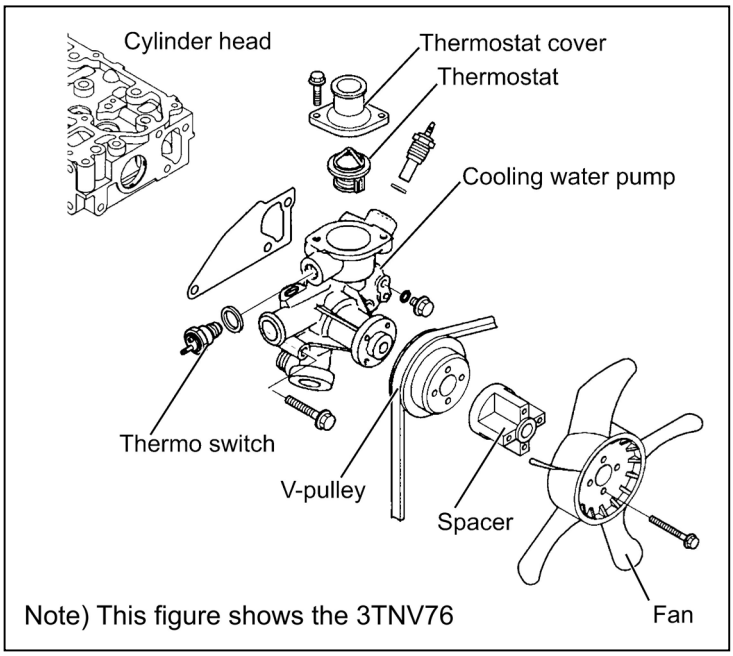
Inspection item	Standard	Limit
Gear case cover I.D.	46.13～46.18	-
Inner rotor O.D.	45.98～46.00	-
Rotor clearance	0.13～0.20	0.25

6. COOLING SYSTEM

6.1 Cooling water System



6.2 Cooling Water Pump Components



6.3 Disassembly (Reverse the below procedure for reassembly)

1) Remove the alternator. (See 4.2.2. 1) in Chapter 4.)
2) Remove the fan, V-belt and pulley. (See 4.2.2. 2) in Chapter 4.)
3) Remove the thermostat case. (See 4.2.2. 3) in Chapter 4.)
4) Remove the cooling water pump. (**Point 1**, in 6.4)
5) Remove the thermostat. (**Point 2** in 6.4)

6.4 Servicing Points

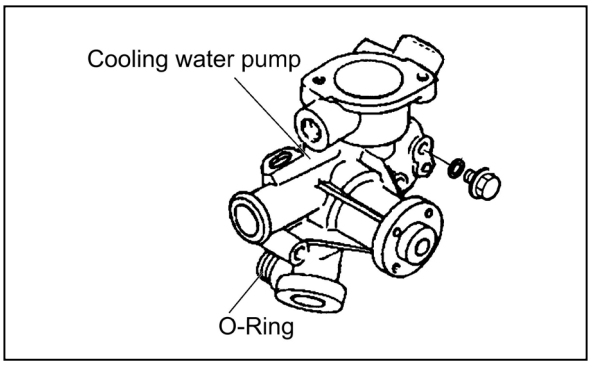
Point1

[Disassemble-Reassemble]

- Check to see that the cooling water pump bearing is free from abnormal noise, sticking or play and water leakage from the bearing. If replacement is necessary, replace the whole cooling water pump assy.

[NOTICE]

Replace the O-ring of the installation part to the cylinder block of the cooling water pump with new one when disassembling. And, be sure to use the special O-ring for each engine model, because the material is different, although the dimension is the same as a commercial part. (Refer to the right figure.)



Point2

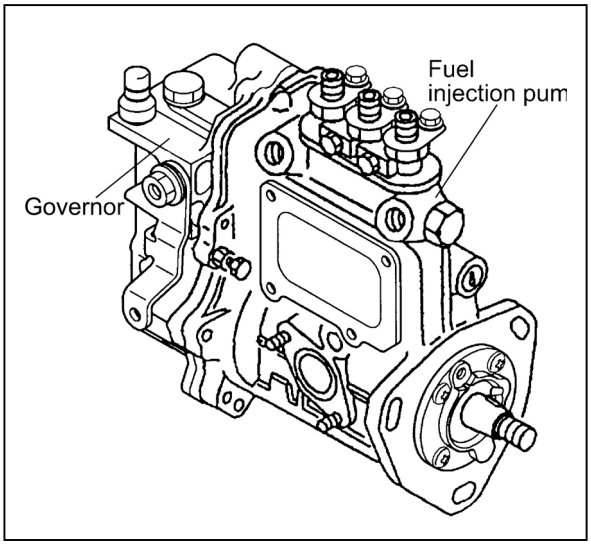
[Disassemble]

- Check the thermostat function. See 2.7 in Chapter 2 for the inspection method.

7. FUEL INJECTION PUMP / GOVERNOR

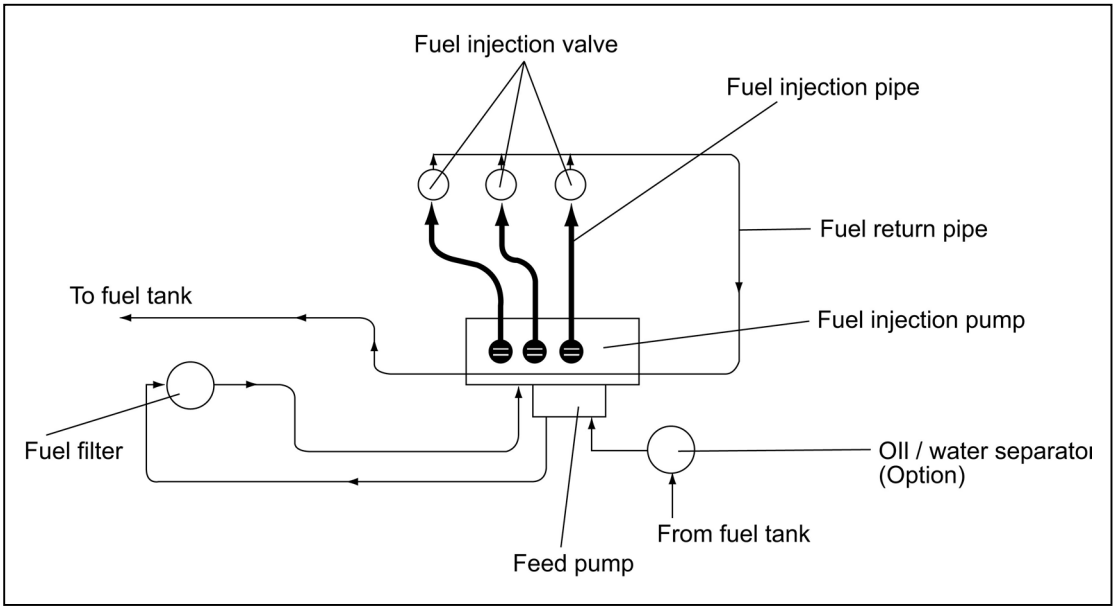
7.1 Introduction

A fuel injection pump is the most important device which adjusts an injection quantity precisely corresponding to the change of engine load.
Therefore, not only a very precise machining should be necessary all parts but also the assembling, adjustment which top-level is excellent in should be necessary.
The careful consideration to avoid dust and rust at the time of disassembly, adjustment, reassembly of the fuel injection pump in the market is necessary.
Fuel injection pumps manufactured by Yanmar, YPES-ML type series are inline type.
A cam shaft is driven through the timing gear, and mechanical type fuel feed pump driven by a cam shaft sends fuel to the fuel filter from the fuel tank.
The fuel which passed through the fuel filter is supplied to the storeroom of the pump housing, and the pressure of the fuel rises by the plunger The fuel passes through the fuel high pressure pipe and the fuel is injected to each cylinder from the fuel injection nozzle.
The manual of the separate volume is referred to for the disassembly and assembly, adjustment procedure of only the YPES-ML type fuel pump.

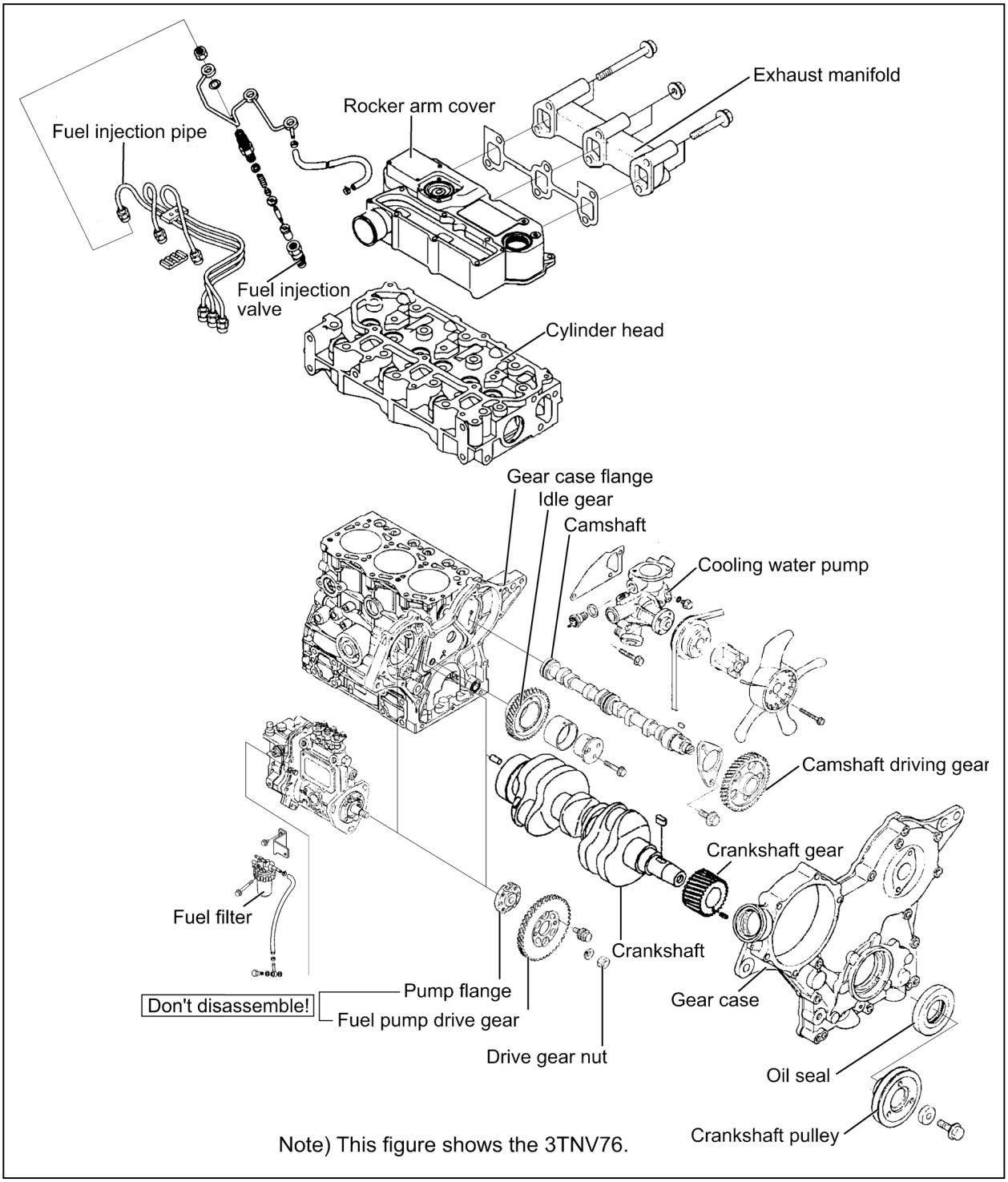


7.2 Fuel Injection Pump

7.2.1 Fuel system diagram

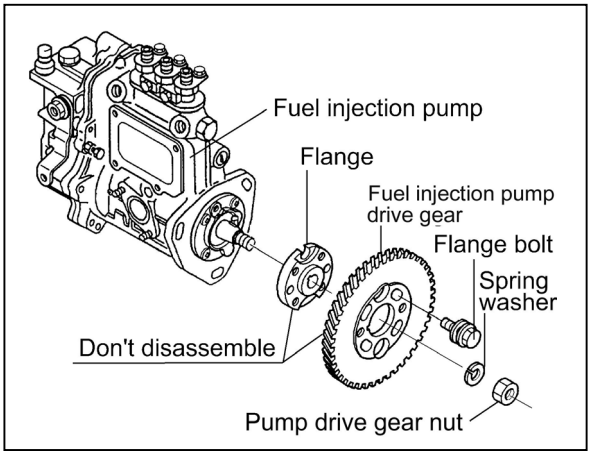


7.2.2 External view and components



7.2.3 Disassembly procedure:

The procedure to remove a fuel injection pump from the gear case is shown.



[NOTICE]
Be sure to remove a flange and a fuel injection pump drive gear with a pair without loosening the flange installation bolts.

1) Remove fuel injection pipes, fuel pipes and a remote control wire. Block the entrance with tape so that trash may not enter the fuel injection pipes and the fuel injection pump.
2) Mark the position of the timing marks of a fuel pump and a gear case. Or, put a mark on the gear case at the position to agree the timing mark of a fuel pump.
3) Remove a pump cover from the gear case.
4) Give the marks on a fuel injection pump drive gear and a idle gear with paint or the like.
5) Loosen fuel injection pump installation nuts (three nuts).
6) Loosen a installation nut of a fuel injection pump drive gear.
7) Move a pump drive gear and a flange with a pair to your side by gear puller.
8) Remove an installation nut and a washer.
9) Remove a fuel injection pump. Leave the pump drive gear in the gear case.

7.2.4 Reassembly procedure

[NOTICE]

- Use a new O-ring on the fuel pump flange and apply grease.
- Confirm whether the marks (7.2.3-4) of the pump drive gear and the idle gear is correct.

1) Turn a cam shaft so that the key of the pump cam shaft may almost agree in a position of the key groove of a pump drive gear.
2) Insert a fuel injection pump into the installation hole of the gear case straight to prevent the damage of the O-ring. Insert a fuel pump with confirming whether the key of a camshaft and the key groove of a drive gear agree.
3) Assemble a pump drive gear installation nut and a washer together temporarily.
4) Turn a fuel injection pump to the position where the marks (7.2.3-2) of the fuel injection pump and the gear case agrees.
5) Fasten pump installation nuts (three nuts).
6) Tighten the pump installation nut which was assembled temporarily by the specified standard torque. Tightening torque of the gear installation nut (with lube oil)

N・m(kgf・m)

Tightening torque
58.8～68.8 (6～7)

7.2.5 Confirmation and adjustment of fuel injection timing

Refer to 2.2.7 in Chapter 2.

7.2.6 Confirmation and adjustment of no-load maximum and minimum speed

Refer to 2.3 in Chapter 2. And, fuel injection pipes, fuel pipes and a remote control wire are installed in the former condition.

[NOTICE]
Monitor the oil and fuel leakage from the fuel pump system or the oil leakage from the fuel pump flange during the engine running.

8. The specifications of a starting motor and the characteristics

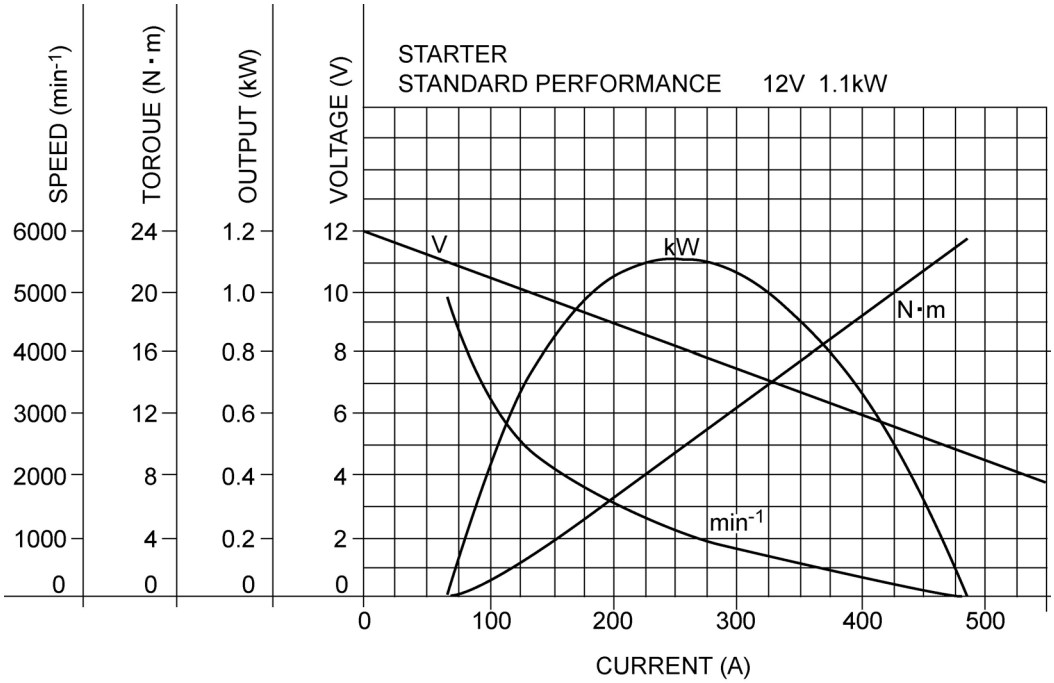
8.1 The specifications and the characteristics

A starting motor turns the ring gear installed on a engine flywheel by the pinion while overcoming resistance such as the compression pressure and the friction loss of the engine and makes the engine start.

8.1.1 Specifications

Manufacturer's model (Denso)		-	P1.1
Yanmar code		-	119717-77010
Nominal output		kW	1.1
Weight		kg	3.0
Revolution direction (as viewed from pinion)		-	Clockwise
Engagement system		-	Magnetic shift
No-load	Terminal voltage/current	V/A	11.5/90 or less
	Revolution	min^{-1}	3000 or above
Loaded	Terminal voltage/current	V/A	2.5/325 or less
	Torque	Nm(kgf·m)	8.24 (0.84)
Clutch system		-	Overrunning
Pinion projection voltage (at 100℃)		V	8.0 or less
Pinion DP or module/number of teeth		-	M2.54/9
Application		-	Standard

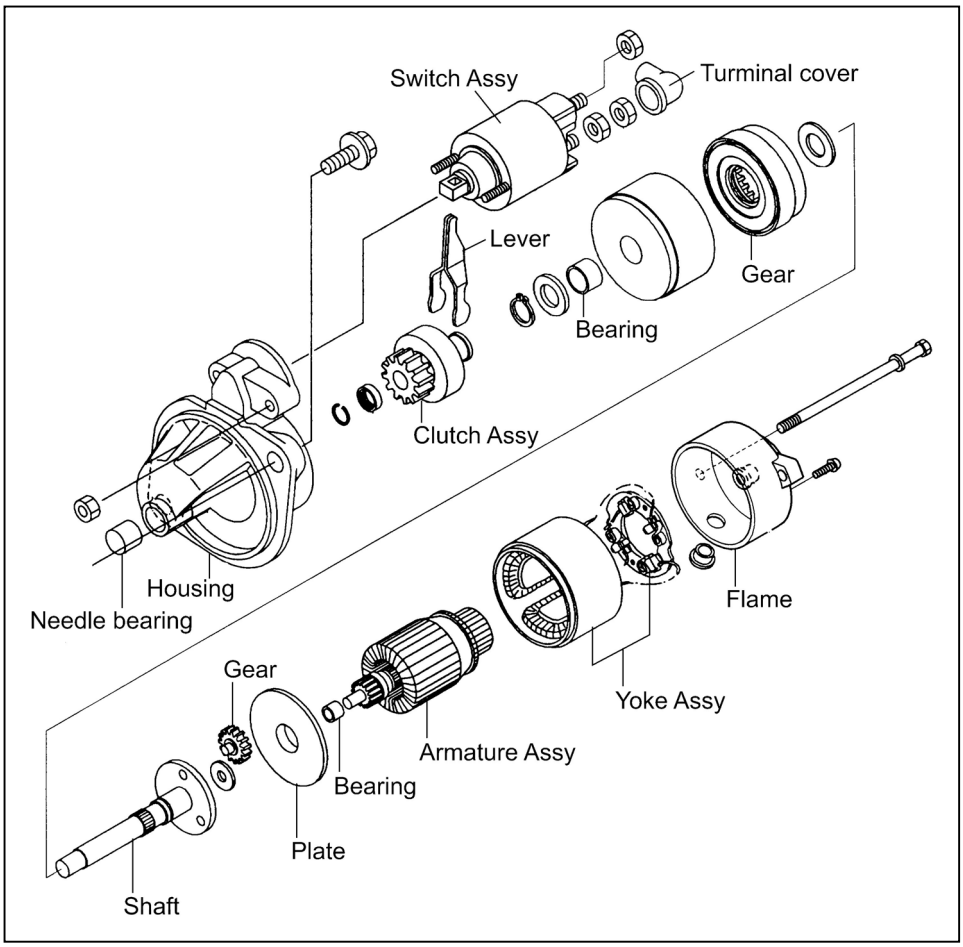
8.1.2 Characteristics



8.2 The structure of a starting motor and the wiring diagram

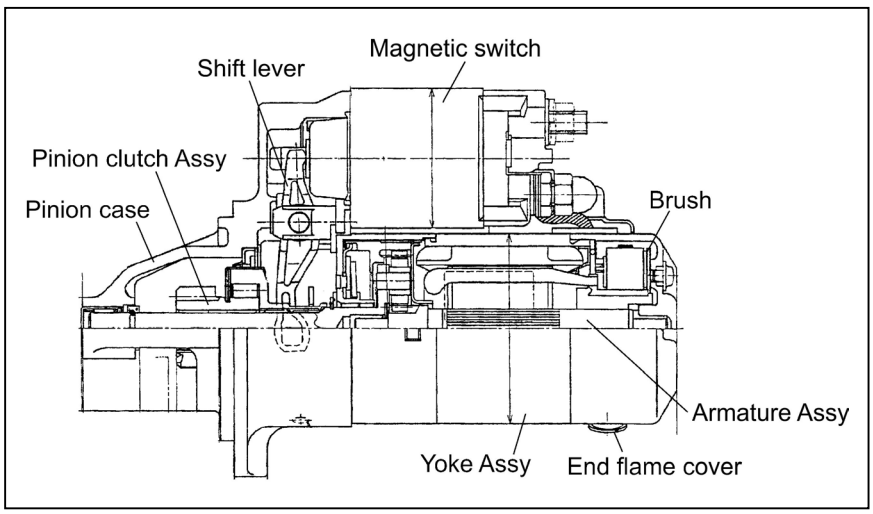
8.2.1 Structure

(1) Disassembly drawing



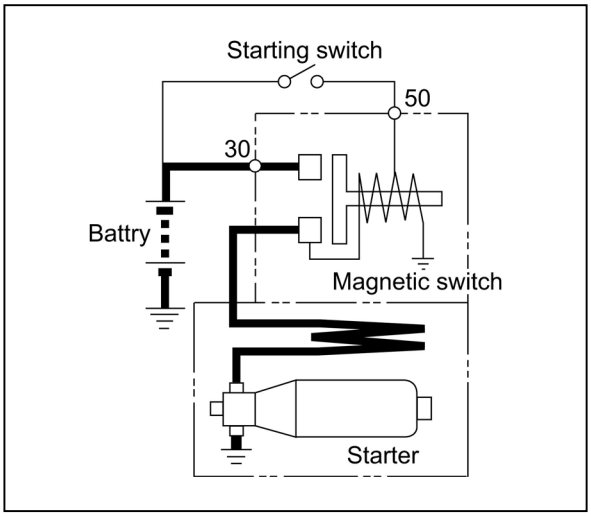
(2) Structure

When the starting switch is turned on, a magnet switch takes a voltage, and a pinion projects. The pinion engages with the ring gear of a engine, and the engine is started.



8.2.2 Wiring diagram of a starting motor

1) When a starting switch is turned on, a magnet switch is charged, and a moving core is absorbed, and a pinion clutch is moved forward through a lever, and the pinion engages with a ring gear.
2) When the pinion engages the ring gear, because a main contact point is closed and the main electric current flows and a pull coil is short-circuited by the main contact point and it stops being charged with electricity, the pinion is kept at the position by a holding coil during the start,
3) When the starting switch is turned off, the main contact point becomes open, and the pinion clutch is returned to the stop position by a return spring.



8.3 Performance

The specified characteristics of a starting motor (at 20 deg. C)

1) No load: Less than electric current 90A, more than rotation speed 3000min^{-1} at voltage 11.5V.
2) Load: More than rotation speed 1130 min-1, torque 6.86 N･m (0.70kg f･m) at voltage 8.7V and electric current 230A.
3) Restraint: Less than electric current 325A, torque 8.2 N･m (0.84 kgf･m) at voltage 2.5V.
4) Operation voltage: In the position of a ring gear, less than 8V

Since the characteristics of a starting motor can be confirmed easily in the no-load test comparatively, perform the test by the next point.

No-load test

Fix the starting motor on a test bench and connect wiring. When the switch is closed, a current flows in the starting motor, which is rotated at no-load. Measure the current, voltage and number of revolutions then and check if they satisfy the specified characteristics.

9. ALTERNATOR

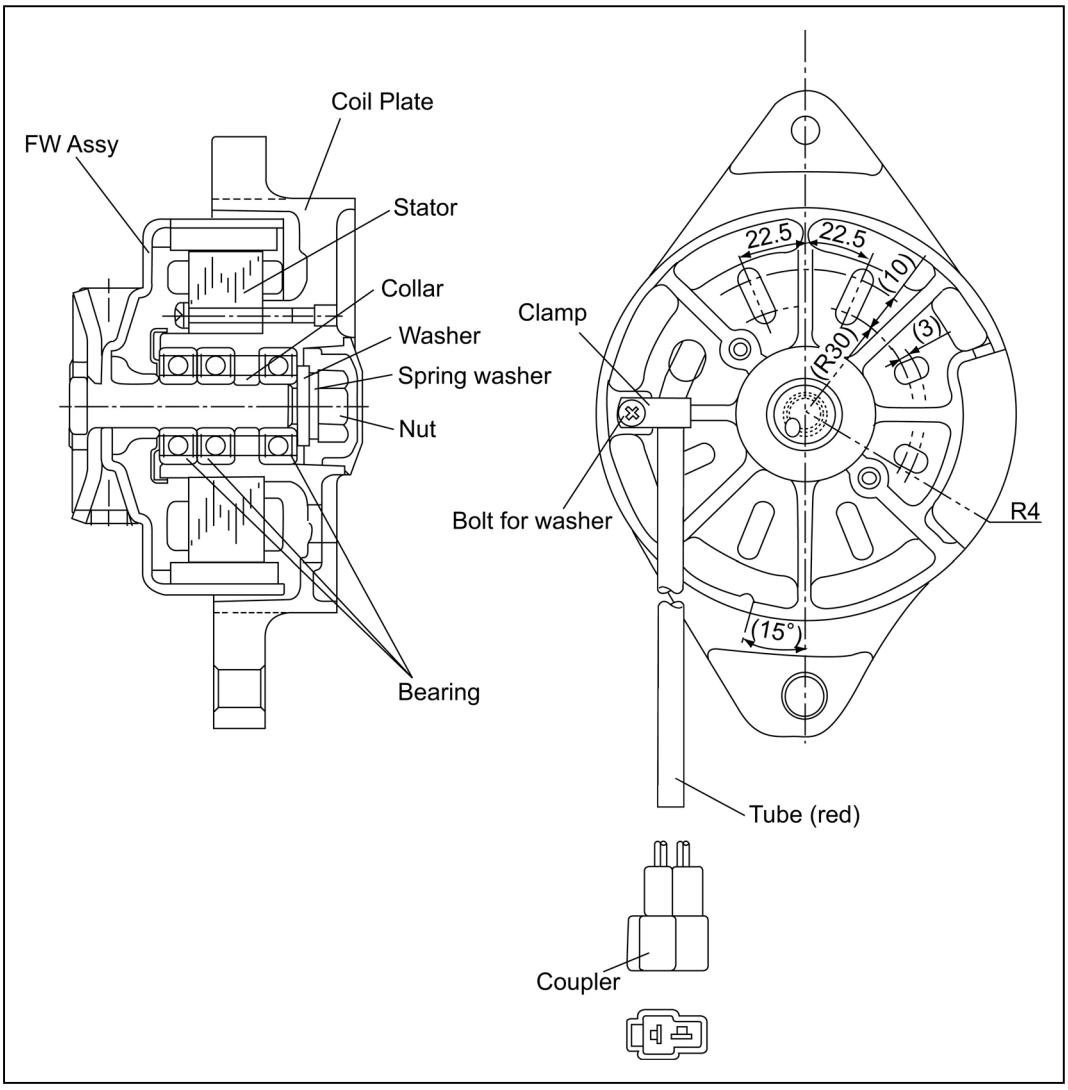
As a representative example of alternator, the alternators of 20A and 40A are shown in this chapter.

9.1 20A Alternator

9.1.1 Specifications

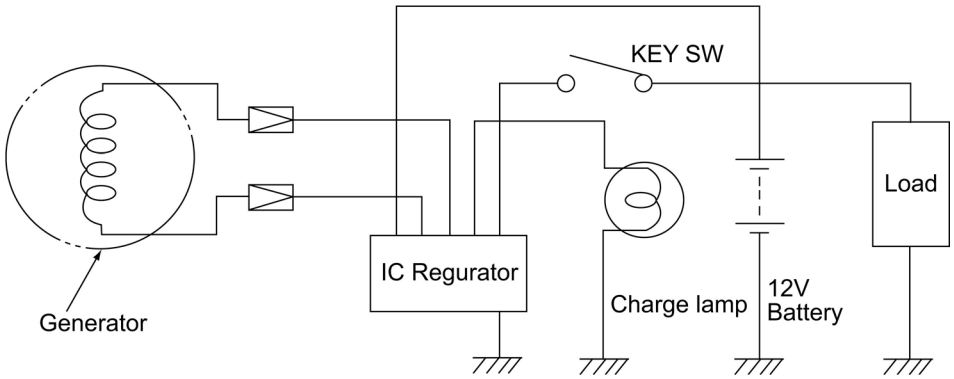
Manufacturer's model (Kokusan)	-	GP9191
Yanmar code	-	119910-77200
Rating	-	Continuous
Battery voltage	V	12
Nominal output	A	20
Rated revolution	min^{-1}	3,500
Operating revolution	min^{-1}	1,400-6,600
Grounding characteristics	-	Minus side grounding
Direction of revolution (viewed from pulley)	-	Clockwise
Integrated regulator		IC regulator
Weight	kg	1.8
Pulley (outside diameter)	mm	65 for A-belt or 58 for special M-belt
Belt shape	-	Type A or type special M

9.1.2 Structure



9.1.3 Wiring diagram

Standard circuit composition for output confirmation

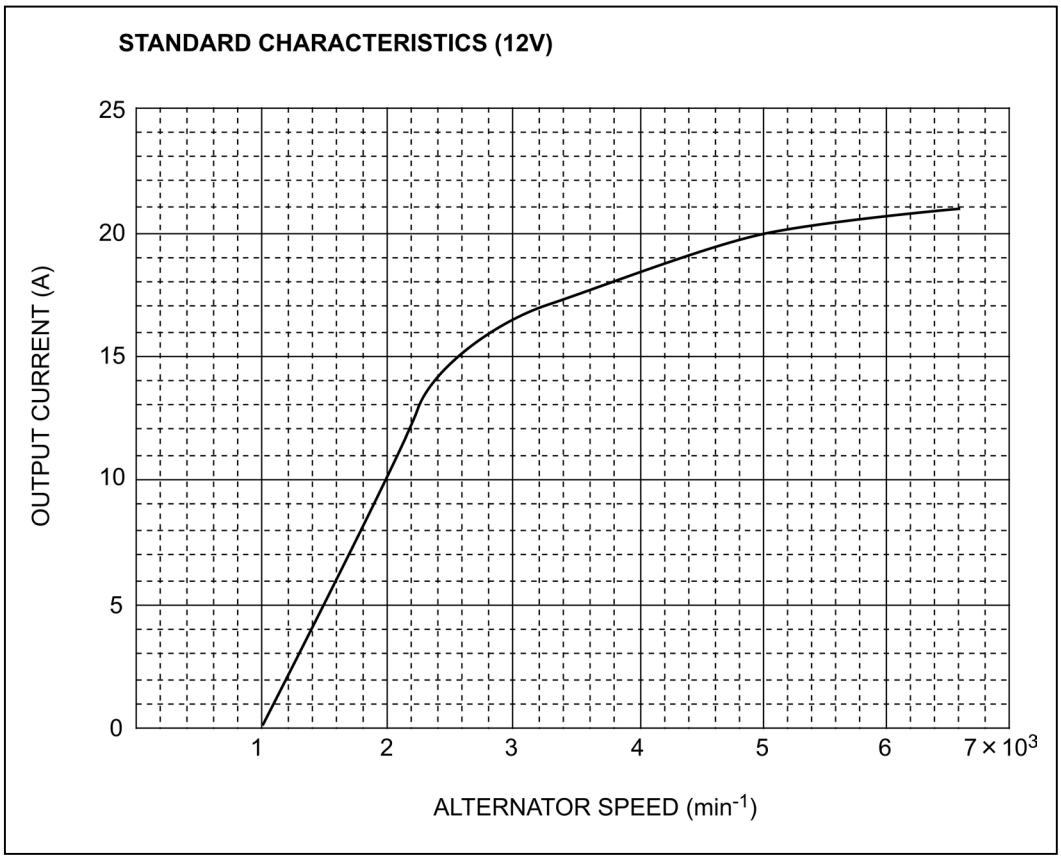


[NOTICE]

1) Don't do mis-connecting and short-circuit of each terminal.
2) Don't remove a battery terminal and a B terminal when rotating.
3) Shut out a battery switch during the alternator stop.

9.1.4 Standard output characteristics

The standard output characteristics of this alternator are shown as the below figure.

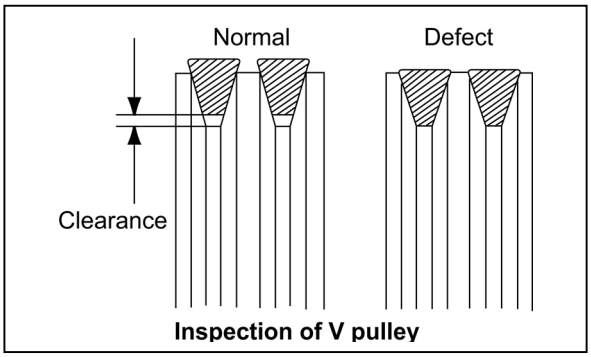


9.1.5 Inspection

(1) V belt inspection

4) Inspect the matter whether there are not crack, stickiness and wear on the belt visually. Check that a belt doesn't touch the bottom part of the pulley groove. If necessary, replace the V belt set.

5) V belt tension:
(Refer to 2.2.2.(2) in Chapter 2.)



Inspection of V pulley

(2) Visual check of wiring and check of unusual sound

1) Confirm whether wiring is right or there is no looseness of the terminal part.

2) Confirm that there is no unusual sound from the alternator during the engine operation.

(3) Inspection of charge lamp circuit

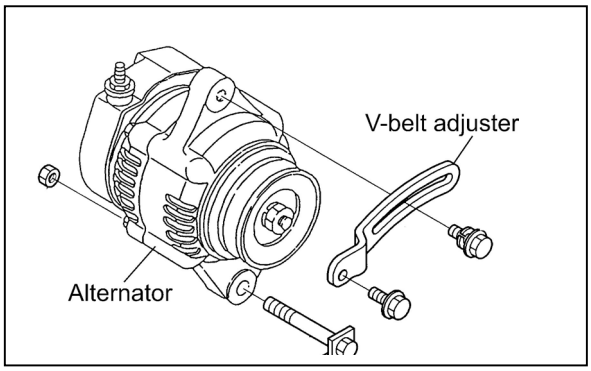
1) Move a start switch to the position of on. Confirm lighting of the charge lamp.

2) Start an engine, and confirm the lights-out of the lamp. Repair a charge lamp circuit when a lamp doesn't work.

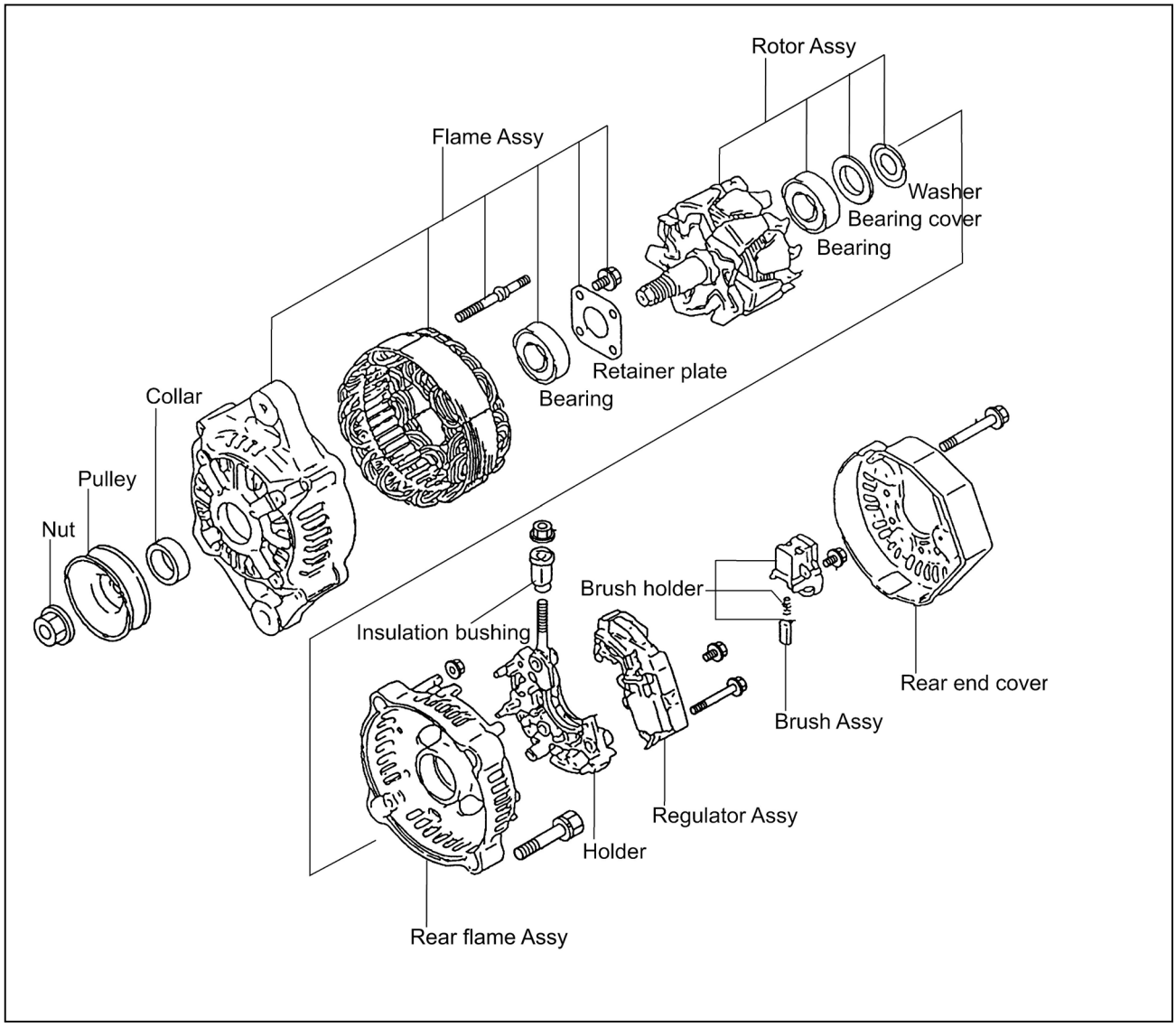
9.2 40A Alternator

9.2.1 Components

(1) Parts related to the alternator



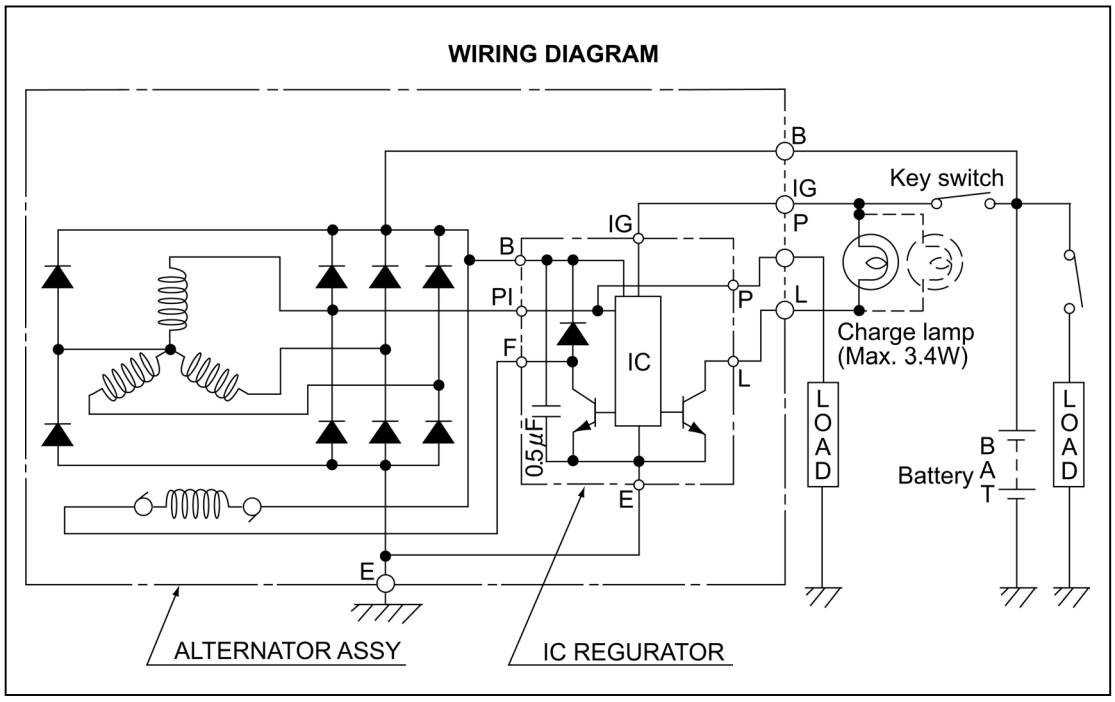
(2) Alternator components of disassembly and assembly



9.2.2 Specifications

Manufacturer's model (Denso)	-	ACFA68
Yanmar code	-	129423-77200
Rating	-	Continuous
Battery voltage	V	12
Nominal output (13.5V heat)	A	40
Rated revolution	min^{-1}	5,000
Operating revolution	min^{-1}	1,350∼18,000
Grounding characteristics	-	Minus side grounding
Direction of revolution (viewed from pulley)	-	Clockwise
Integrated regulator		IC regulator
Weight	kg	2.8
Pulley (outside diameter)	mm	69.2
Belt shape	-	Type A

9.2.3 Wiring diagram

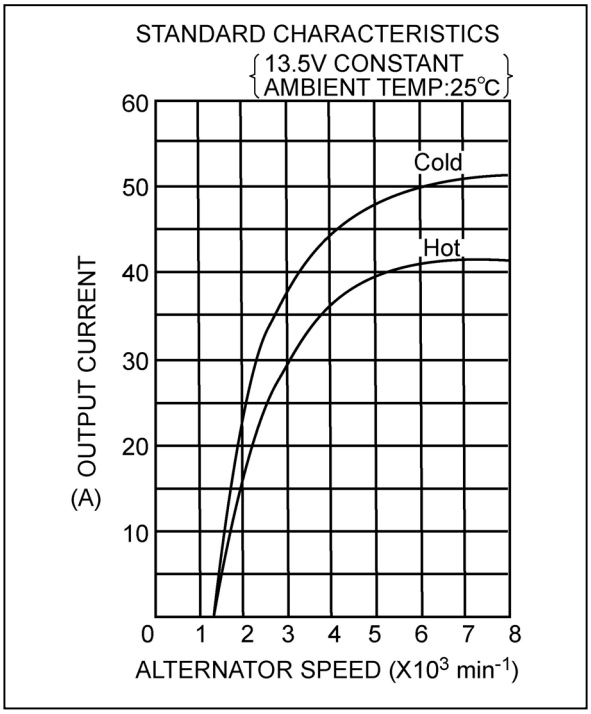


[NOTICE]

1) Don't do mis-wiring and short-circuit of each terminal.
2) Don't remove a battery terminal and a B terminal when rotating.
3) Shut out a battery switch during the alternator stop.

9.2.4 Standard output characteristics

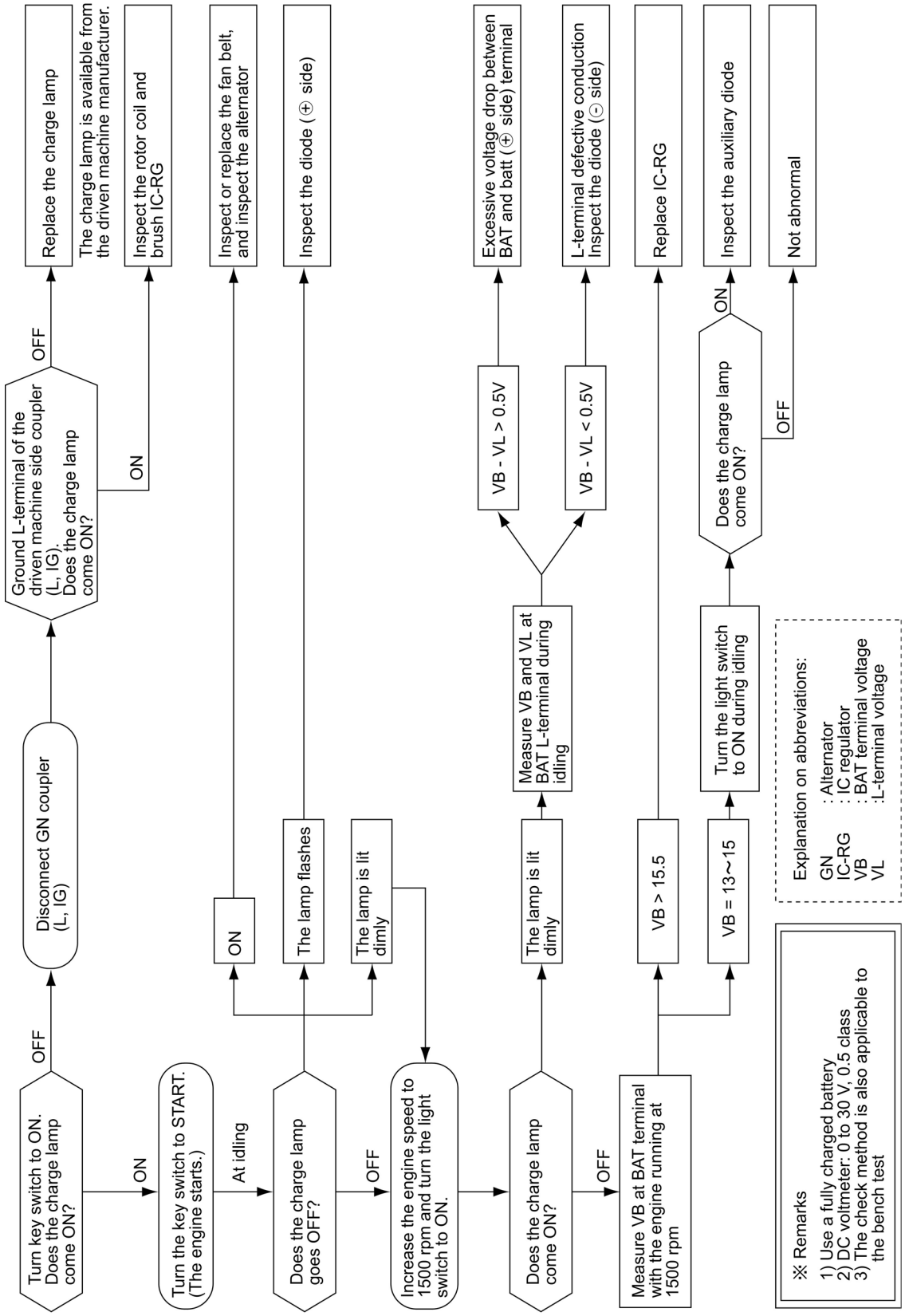
The standard output characteristics of this alternator are shown as the right figure.



9.2.5 Inspection

Perform the same procedure as that of 9.1.5 in Chapter 9.

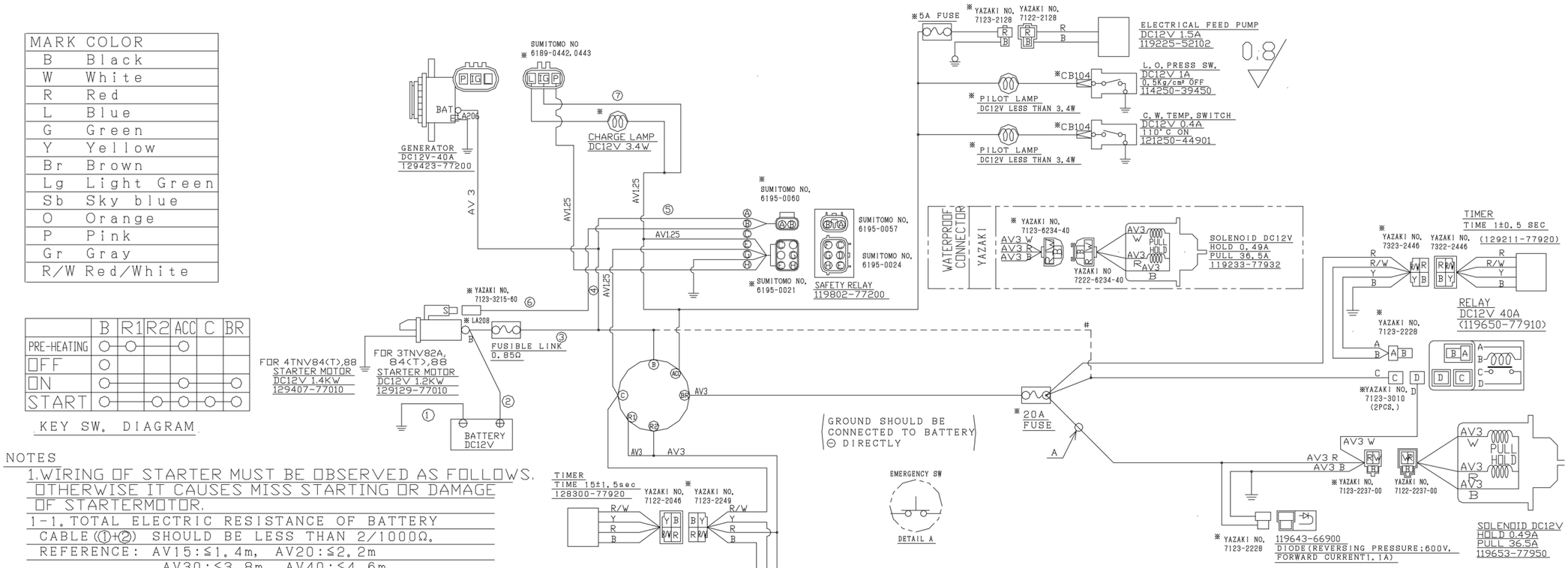
9.3 Troubleshooting


Turn key switch to ON. Does the charge lamp come ON?
OFF
Disconnect GN coupler (L, IG)
ON
Turn the key switch to START. (The engine starts.)
At idling
Does the charge lamp goes OFF?
OFF
Increase the engine speed to 1500 rpm and turn the light switch to ON.
Does the charge lamp come ON?
OFF
Measure VB at BAT terminal with the engine running at 1500 rpm
Ground L-terminal of the driven machine side coupler (L, IG). Does the charge lamp come ON?
OFF
Replace the charge lamp
The charge lamp is available from the driven machine manufacturer.
ON
Inspect the rotor coil and brush IC-RG
ON
Inspect or replace the fan belt, and inspect the alternator
The lamp flashes
Inspect the diode (⊕ side)
The lamp is lit dimly
The lamp is lit dimly
Measure VB and VL at BAT L-terminal during idling
VB - VL > 0.5V
Excessive voltage drop between BAT and batt (⊕ side) terminal
VB - VL < 0.5V
L-terminal defective conduction Inspect the diode (⊖ side)
VB > 15.5
Replace IC-RG
VB = 13～15
Turn the light switch to ON during idling
Does the charge lamp come ON?
ON
Inspect the auxiliary diode
OFF
Not abnormal
※ Remarks
1) Use a fully charged battery
2) DC voltmeter: 0 to 30 V, 0.5 class
3) The check method is also applicable to the bench test
Explanation on abbreviations:
GN : Alternator
IC-RG : IC regulator
VB : BAT terminal voltage
VL :L-terminal voltage

10. Electric Wiring

10.1 Electric Wiring Diagram

This is a typical example.



NOTES

1. WIRING OF STARTER MUST BE OBSERVED AS FOLLOWS. OTHERWISE IT CAUSES MISS STARTING OR DAMAGE OF STARTERMOTOR.
1-1. TOTAL ELECTRIC RESISTANCE OF BATTERY CABLE (①+②) SHOULD BE LESS THAN 2/1000Ω. REFERENCE: AV15:≦1.4m, AV20:≦2.2m AV30:≦3.8m, AV40:≦4.6m
1-2. TOTAL ELECTRIC RESISTANCE OF WIRING FOR STARTER (③~⑥) SHOULD BE LESS THAN 5/100Ω. REFERENCE OF TERMINAL RESISTANCE : 15/1000Ω PER COUPLER 0Ω PER SCREW SETTIG
1-3. BATTERY EARTH CABLE (①) CONNECTION SHALL BE ENSURED. PAINTED SURFACE MAY NOT BE USED (FOR EARTHING) AVOIDING THE MISS CONTACT.
2. BATTERY TREATMENT MUST BE OBSERVED AS FOLLOWS. OTHERWISE IT MAY CAUSE BURNING OF ELECTRIC EQUIPMENTS OR COMPONENTS. ALTERNATOR (DIODES) BURNING CAUSED BY BATTERY CABLE CONNECTION REVERSELY IS NOT WARRANTED.
2-1. BATTERY SHOULD BE FIXED BY FITTING. (NOT TO MOVE)
2-2. BATTERY CABLE LENGTH SHOULD BE ADJUSTED PROPERLY AND CLAMPED NOT TO BE CONNECTED REVERSELY.
2-3. NOT LOOSE THE BATTERY CABLE TERMINAL, NOR TURN THE BATTERY SWITCH OFF DURING THE ENGINE RUNNING.
3. ONLY THE SPECIFIED LOAD SHOULD BE APPLIED ON THE ALTERNATOR "L" AND "P" LINE. IT IS NOT ALLOWED TO CONNECT ANY LOAD UNSPECIFIED WITHOUT YANMAR APPROVAL.
4. CHECK ANY SURGE CURRENT OR VOLTAGE OCCURED UNDER NORMAL OPERATIONS AND EXPECTIVE ERRONEOUS OPERATIONS, AND CONFIRM THE CIRCUIT NO SURGE OCCURS. ESPECIALLY PROVIDE THE FLYWHEEL DIODE FOR "C-LOAD" AND DIODE FOR "L-LOAD".

NOTES FOR ENGINE STOP SOLENOID

1. PERMISSIBLE RESISTANCE OF SOLENOID CIRCUIT SHOULD BE LESS THAN 0.07Ω TO GUARANTEE PERMISSIBLE LOWEST VOLTAGE 9V TO WORK SOLENOID(PULL COIL). (TERMINAL RESISTANCE :15/1000Ω PER COUPLER, 0Ω PER SCREW SETTING. COUPLER RESISTANCE OF SOLENOID DOESN'T NEED TO BE COUNTED) REFERENCE :AV2(0.0088Ω/m):≦8.0m・・・WITHOUT TERMINAL RESISTANCE AV3(0.0056Ω/m):≦12.5m・・・SAME AS ABOVE WHEN YOU EXCEED PERMISSIBLE RESISTANCE, ADOPT THE CIRCUIT IMPRESSED FROM THE POWER SUPPLY TO THE SOLENOID DIRECTLY USING A RELAY ・・・REFER TO #
2. HIGH TEMPERATURE PARTS, SUCH AS AN EXHAUST PIPE, SHOULD NOT APPROACH FOR THE PULL POWER FALL OF SOLENOID, AND HEATING PREVENTION OF INNER COIL TEMPERATURE. (PERMISSIBLE AMBIENT TEMPERATURE:-30~100℃)
3. INSTALL FUSE TO PROTECT THE HARNESS AGAINST TROUBLES SUCH AS SHORT CIRCUIT OR CONTINUOUS DRIVE OF PULL-COIL.
4. THE POWER SUPPLY OF SOLENOID MAY NOT BE COMMON WITH THE LINE OF ALTERNATOR INITIAL EXCITATOR AS SHOWN IN THIS DRAWING. (OTHERWISE, SOLENOID MAY LOOSE STOP FUNCTION DUE TO THE POWER SUPPLY FROM ALTERNATOR "L" TERMINAL.)
5. IN CASE OF WATERPROOF CONNECT OR APPLICATION, CONNECTOR SHOULD BE FIXED BY FITTING TO PREVENT LEAD WIRE BREAK.
6. IN CASE OF EMARGENCY STOP OF MACHINE FOR SAFETY WILL BE APPLIED SWITCH LOCATION SHOULD BE SHOWN AS A.
7. IN CASE OF THE SOLENOID CIRCUIT RESISTANCE WOULD BE LIMIT, # WIRING IS APPLICABLE.

REMARKS

1. ※ MARKED PARTS ARE NOT PROVIDED BY YANMAR.

10.1.1 Alternator

In the cases listed below the warranty shall not be deemed to apply. Please be sure to read these conditions carefully when planning to use it with other equipment. Also be certain to give appropriate guidance on usage to the user.

(1) When the battery cable can be connected backwards
The alternator diode will be damaged and recharging made impossible if the plus and minus ends of the battery cable are confused. The stator coil will also be burned as a result. To prevent this, supply the user with a cable of such a length or structure that the plus and minus ends cannot be confused. Also warn the user not to connect the cable backwards.

(2) When charging output voltage is used for control purposes
The engine speed at starting is not proportional to the output voltage of the alternator, so this output voltage must not be used for any control systems. It is especially wrong to use it for the control signal of the safety relay for cutting the starting motor because this will damage the starting motor and cause engine starting failure.

(3) When the L line is used for control purposes
Consult with Yanmar first before connecting any load other than the charge lamp to the L line. Damage to the alternator and related equipment will not be warranted without such prior consultation.

(4) Non-use of the Yanmar wiring diagram
Use without prior consultation of any wiring diagram other than that provided by Yanmar removes any breakdown of any electrical equipment from the warranty.

(5) Regarding lamp control
Once the charge lamp goes out after the start of charging, it does not come on again even if the engine speed falls and charging is insufficient. The lamp will not light again if the charging circuit is normal. The lamp only comes on during operation if the alternator itself is broken or the drive V-belt breaks. However, when an LED is used for the charge lamp, the LED will shine faintly even during normal operation. This is due to the control system for the alternator lamp and is not an abnormality.

(6) Use of a non-specified V-belt
Use of a non-specified V-belt will cause inadequate charging and shorten the life of the belt. Use a belt of the specified type.

(7) Direct high pressure washing is prohibited
Water will enter the brush if the alternator is washed directly at high pressure, causing inadequate charging. Warn users not to use direct, high-pressure washing.

(8) Adhesion of agricultural and other chemicals (direct contact or airborne)
Adhesion of agricultural and other chemicals, especially those with high sulfur content, to the IC regulator corrodes the conductor on the substrate, leading to over-charging (battery boiling) and charging malfunctions. Consult with Yanmar prior to using the engine in such an environment. Use without prior consultation removes any breakdown from the warranty.

10.1.2 Starting motor

In the cases listed below the warranty shall not be deemed to apply. Please be sure to read these conditions carefully when planning to use it with other equipment. Also be certain to give appropriate guidance on usage to the user.

(1) Starting performance in the case of using an untested battery

The starting performance of the engine is closely dependent on the battery capacity. This battery capacity is itself affected by the climate and the type of equipment installation. The details regarding ambient temperature and equipment installation vary depending on the OEM, so Yanmar cannot decide the battery capacity on its own. Confer with Yanmar in advance after checking these conditions and fix the battery capacity on the basis of confirmatory tests.

(2) When the resistance of the battery cable exceeds the specified value

The combined total resistance of the battery cable in both directions between the starting motor and battery should be within the value indicated on the wiring diagram. The starting motor will malfunction or break down if the resistance is higher than the specified value.

(3) When the resistance of the starting motor circuit exceeds the specified value

The combined total resistance of the wiring between the starting motor and key switch (or power relay or safety relay, depending on the application) should be within the value indicated on the wiring diagram. Engine starting will be difficult if the resistance is higher than the specified value. This can also cause welding of the magnet switch at the point of contact and resultant burning of the armature coil.

(4) When there is no safety relay

Over-running (when the electric current flows for too long) is a major cause of starting failure. This burns the armature coil and causes clutch failure. Excessive work and failure of the key switch to return properly are the main causes of over-running. The user must be given sufficient warning about this.

Be sure to use the safety relay to prevent over-running. This safety relay is supplied as an option. Consult Yanmar first when planning to install a safety relay at your own company. In the case of failure to consult with Yanmar, our warranty will not be applied to all the electrical equipment.

(5) When there is too much rust due to the entry of water

The water-proofing of the starting motor is equivalent to R2 of JIS D 0203. This guarantees that there will be no damage from the sort of exposure encountered in rain or when water is poured on from a bucket. You should, however, avoid the use of high-pressure washing and steeping in water.

(6) Regarding the heat resistance of the starter motor

The starting motor has heat resistance for an ambient temperature of 80℃ and surface temperature of 100℃. Insulators must be installed to prevent overheating when used near high temperature parts such as the exhaust system.

(7) Corrosion of magnet switch contact point by corrosive gas.

When using equipment with a dry clutch, ammonium gas generated by friction is liable to corrode the contact of the magnet switch. Be sure to install a vent in the clutch case.

10.1.3 Current limiter

In the cases listed below the warranty shall not be deemed to apply. Please be sure to read these conditions carefully when planning to use it with other equipment. Also be certain to give appropriate guidance on usage to the user.

(1) When an over-discharged battery is used

Use of booster starting with an over-discharged battery (when the voltage has dropped to 8V or less) will destroy other electrical equipment by generating an abnormally high voltage. A specialized battery charger should be used to recharge such an over-discharged battery (when the voltage has dropped to 8V or less).

(2) When checks for malfunctioning are not performed

When high voltage noise from other electrical equipment is impressed on the current limiter upon turning off the key switch, the current limiter can be damaged and cause loss of control over the output voltage. Other electrical equipment may also be damaged if this happens, so surge killers should be fitted to the electrical equipment whenever necessary. Be sure to check prior to mass production whether electrical noise might damage the current limiter by turning the key switch and other electrical equipment on and off while the engine is running, using both the vehicle and the wire harness that will be used in mass production.

(3) Removal of the battery cable during operation

The current limiter may malfunction if the battery cable and/or battery are removed during operation, depending on the kind of electrical equipment being used, causing loss of control over the output voltage. In such cases, the current limiter and other electrical equipment will be damaged by the generation of a continuous high voltage of 24-43V (for 5,000rpm dynamo). All electrical equipment falls outside the scope of the warranty under these circumstances. Be sure to warn the user not to remove the battery cable and/or battery during operation.

(4) If the battery cable can be attached in reverse

The current limiter's SCR diode will be destroyed if the plus and minus ends of the battery cable are connected the wrong way around. This causes charging malfunctioning and burns the harness. Give the user a cable of such a length that it cannot be connected the wrong way and warn the user against connecting the cable backwards.

(5) Non-use of the Yanmar wiring diagram

Use without prior consultation of any wiring diagram other than that provided by Yanmar removes any breakdown of any electrical equipment from the warranty.

(6) Installation environment

Observe the following when installing the current limiter:

1) Do not install it on the engine.
2) Place it in a well-ventilated place with an ambient temperature of 65℃ or less.
3) Ensure that the cooling air flows in the right direction for the current limiter's cooling fins.
4) Do not use the earth wire of the current limiter to earth any other electrical equipment.

10.1.4 Section area and resistance of electric wire

(1) Allowable maximum cable length （Terminal resistance is not included.）

Cable size mm^2	Cable construction		Resistance (Ω/m)	2mΩ Note1 (m)	20mΩ Ref. (m)	50mΩ Note2 (m)
	Element No.	Cable dia.				
3	41	ϕ0.32	0.005590	0.36	3.58	8.94
5	65	ϕ0.32	0.003520	0.57	5.68	14.20
8	50	ϕ0.45	0.002320	0.86	8.62	21.55
15	84	ϕ0.45	0.001380	1.45	14.49	36.23
20	41	ϕ0.80	0.000887	2.25	22.55	56.37
30	70	ϕ0.80	0.000520	3.85	38.46	96.15
40	85	ϕ0.80	0.000428	4.67	46.73	116.82
50	108	ϕ0.80	0.000337	5.93	59.35	148.37
60	127	ϕ0.80	0.000287	6.97	69.69	174.22
85	169	ϕ0.80	0.000215	9.30	93.02	232.56
100	217	ϕ0.80	0.000168	11.90	119.05	297.62

Note1) Allowable maximum resistance of Battery cable
Note2) Allowable maximum resistance of Starting motor circuit

(2) Terminal resistance
Generally, a terminal resistance is 15mΩ per coupler and 0Ω per screw setting. This resistance should be included in allowable maximum resistance when the cable length is planned.

11. SERVICE STANDARDS

11.1 Engine Tuning

No.	Inspection item			Standard		Limit	Reference page
1	Gap at intake/exhaust valve heads mm			0.15～0.25		-	2.2.6(3)
2	V-belt tension mm at 98N (10kgf)	Between alternator and crank pulley (Direction A)	Used part	10～14		-	2.2.2.(2)
			New part	8～12		-	
		Between alternator and radiator fan (Direction S)	Used part	7～10		-	
			New part	5～8		-	
		Between radiator fan and crank pulley (Direction C)	Used part	9～13		-	
			New part	7～11		-	
3	Fuel injection pressure MPa (kgf/cm^2)			11.8～12.8 (120～130)		-	2.2.6.(4)
4	Fuel injection timing FID degrees (bTDC)			Refer to 2.2.7(4) in chapter 2.		-	2.2.7.(4)
5	Compression pressure (at 250 min^{-1}) MPa(kgf/cm^2)	2/3TNV70		3.24(33)±0.1(1)		2.55(26)±0.1(1)	3.3
		3TNV76		3.43(35)±0.1(1)		2.75(28)±0.1(1)	
6	Cooling water Capacity (Only engine body) (Liter)	2TNV70		0.6		-	2.2.1.(4)
		3TNV70/76		0.9		-	
7	Lube oil capacity (oil pan) (Liter)	Model		Total	Effective		2.2.1.(3)
		2TNV70(VM)		1.7	0.7	-	
		3TNV70(VH/VM)		2.8	1.3	-	
		3TNV70(CH)		3.8	1.7	-	
		3TNV76(VM/VH)		3.5	1.6	-	
		3TNV76(CH)		4.4	2.1	-	
8	Lube oil pressure MPa (kgf/cm^2)			at rated speed		at low idle speed	-
				0.29(3.0)～0.44(4.5)		0.06(0.6) or above	-
9	Oil pressure switch operating pressure MPa (kgf/cm^2)			0.05±0.01 (0.5±0.1)		-	-
10	Thermostat			valve opening temperature deg. C		Full opening lift (mm) (temperature)	2.7
				69.5～72.5		8 or above (85 deg.C)	
11	Thermo switch actuating temperature (deg.C)			107～113		-	2.4(2)

*Lube oil capacity may differ from the above depending on an engine installed on a machine unit.

11.2 Engine Body

11.2.1 Cylinder head

(1) Cylinder head

Inspection item			Standard	Limit	Reference page
Combustion surface distortion mm			0.05 or less	0.15	4.2.5.(1)
Valve sink mm		Intake	0.4∼0.6	0.9	
		Exhaust	0.4∼0.6	0.8	
Valve seat	Seat angle Deg.	Intake	120	-	4.2.6.
		Exhaust	90	-	
	Seat correction angle deg.		40, 150	-	

(2) Intake/exhaust valve and guide

mm

Inspection item		Standard	Limit	Reference page
Intake	Guide inside diameter	6.000∼6.012	6.08	4.2.5.(2)
	Valve stem outside diameter	5.960∼5.975	5.90	
	Clearance	0.025∼0.052	0.16	
Exhaust	Guide inside diameter	6.000∼6.012	6.08	
	Valve stem outside diameter	5.945∼5.960	5.90	
	Clearance	0.040∼0.067	0.17	
Valve guide projection from cylinder head		9.8∼10.0	-	4.2.7.
Valve guide driving-in method		Cold-fitted	-	

(3) Valve spring

mm

Inspection item	Standard	Limit	Reference page
Free length	37.8	-	4.2.5.(4)
Inclination	-	1.3	

(4) Rocker arm and shaft

mm

Inspection item	Standard	Limit	Reference page
Arm shaft hole diameter	12.000∼12.020	12.07	4.2.5.(5)
Shaft outside diameter	11.966∼11.984	11.94	
Clearance	0.016∼0.054	0.13	

(5) Push rod

mm

Inspection item	Standard	Limit	Reference page
Bend	-	0.03	4.2.5.(7)

11.2.2 Gear train and camshaft

(1) Camshaft

mm

Inspection item		Standard	Limit	Reference page
Side gap		0.05～0.15	0.25	4.3.4
Bending (1/2 the dial gage reading)		0～0.02	0.05	4.3.5(1)
Cam height		34.135～34.265	33.89	
Shaft outside diameter / Metal inside diameter				
Gear side	Bushing inside diameter	40.000～40.075	40.150	4.3.5(1)
	Camshaft outside diameter	39.940～39.960	39.905	
	Clearance	0.040～0.135	0.245	
Intermediate (No bushing)	Bushing inside diameter	40.000～40.025	40.100	
	Camshaft outside diameter	39.910～39.935	39.875	
	Clearance	0.065～0.115	0.225	
Wheel side (No bushing)	Bushing inside diameter	40.000～40.025	40.100	
	Camshaft outside diameter	39.940～39.960	39.905	
	Clearance	0.04～0.085	0.195	

(2) Idle gear shaft and bushing

mm

Inspection item	Standard	Limit	Reference page
Shaft outside diameter	45.950～49.975	45.900	4.3.5(2)
Bushing inside diameter	46.000～46.025	46.075	
Clearance	0.025～0.075	0.175	

(3) Backlash of each gear

mm

Inspection item	Standard	Limit	Reference page
Crank gear, cam gear, idle gear, fuel injection pump gear and PTO gear	0.06～0.12	0.14	4.3.4.

11.2.3 Cylinder block

(1) Cylinder block

mm

Inspection item		Standard	Limit	Reference page
Cylinder inside diameter	2/3TNV70	70.010～70.020	70.200	4.4.5.(1)
	3TNV76	76.010～76.020	76.200	
Cylinder bore	Roundness	0.01 or less	0.03	
	Cylindricity			

(2) Crankshaft

mm

Inspection item		Standard	Limit	Reference page
Bending (1/2 the dial gauge reading)		-	0.02	4.4.5.(2)
Roundness		0.01 or less	0.02	
Crank pin	Pin outside diameter	41.952～41.962	42.902	
	Metal inside diameter	41.982～42.002	-	
	Metal thickness	1.503～1.509	-	
	Clearance	0.020～0.050	0.110	
Crank journal	Journal outside diameter	46.952～46.962	46.902	
	Metal inside diameter	46.982～47.002	-	
	Metal thickness	2.009～2.014	-	
	Clearance	0.020～0.050	0.120	

(3) Thrust bearing

mm

Inspection item	Standard	Limit	Reference page
Crankshaft side gap	0.111～0.250	-	4.4.5(3)
Metal thickness	1.930～1.980	1.850	

(4) Piston and ring

Piston

mm

Inspection item		Standard	Limit	Reference page
Piston outside diameter (Measure in the direction vertical to the piston pin.)	2/3TNV70	69.960～69.990	69.915	4.4.5.(4)
	3TNV76	75.955～75.985	75.910	
Piston diameter measure position (Upward from the bottom end of the piston)	2/3TNV70 3TNV76	22～25	-	
Piston pin	Hole inside diameter	22.000～22.009	22.039	
	Pin outside diameter	21.995～22.000	21.965	
	Clearance	0.000～0.014	0.074	

Piston ring

mm

Model	Inspection item		Standard	limit	Reference page
2/3TNV70	Top ring	Ring groove width	1.550～1.570	-	4.4.5.(4)
		Ring width	1.470～1.490	1.450	
		Side clearance	0.060～0.100	-	
		End clearance	0.15～0.30	0.39	
	Second ring	Ring groove width	1.540～1.560	1.660	
		Ring width	1.470～1.490	1.450	
		Side clearance	0.050～0.090	0.210	
		End clearance	0.18～0.33	0.42	
	Oil ring	Ring groove width	3.010～3.030	3.130	
		Ring width	2.970～2.990	2.950	
		Side clearance	0.020～0.060	0.180	
		End clearance	0.20～0.45	0.54	
3TNV76	Top ring	Ring groove width	1.550～1.570	-	
		Ring width	1.470～1.490	1.450	
		Side clearance	0.060～0.100	-	
		End clearance	0.15～0.30	0.390	
	Second ring	Ring groove width	1.580～1.595	1.695	
		Ring width	1.430～1.450	1.410	
		Side clearance	0.013～0.165	0.285	
		End clearance	0.18～0.33	0.420	
	Oil ring	Ring groove width	3.010～3.025	3.125	
		Ring width	2.970～2.990	2.950	
		Side clearance	0.020～0.055	0.175	
		End clearance	0.20～0.45	0.540	

(5) Connecting rod

mm

Inspection item	Standard	Limit	Reference page
Thrust clearance	0.2～0.4	-	4.4.4

Rod small end

mm

Item	Standard	Limit	Reference page
Bushing inside diameter	22.025～22.038	22.068	4.4.5.(5)
Pin outside diameter	21.991～22.000	21.963	
Clearance	0.025～0.047	0.105	

(6) Tappet

mm

Inspection item	Standard	Limit	Reference page
Tappet hole (block) inside diameter	21.000～21.021	21.041	4.4.5.(6)
Tappet stem outside diameter	20.927～20.960	20.907	
Clearance	0.040～0.094	0.134	

11.3 Lubricating Oil System (Trochoid Pump)

(1) Outside clearance of outer rotor

mm

Standard	Limit	Reference page
0.12～0.21	0.30	5.5.1

(2) Side clearance of outer rotor

mm

Standard	Limit	Reference page
0.02～0.07	0.12	5.5.1

(3) Outside clearance of inner rotor centering location part

mm

Standard	Limit	Reference page
0.13～0.20	0.25	5.5.1

12. Tightening Torque for Bolts and Nuts

12.1 Tightening Torques for Main Bolts and Nuts

Part and engine model		Thread diameter × pitch mm	Tightening torque N·m(kgf·m)	Lube oil application (thread portion, and seat surface)	Reference page
Cylinder head bolt		M9×1.25	53.9～57.9 (5.5～5.9)	Applied	4.2.4
Connecting rod bolt		M7×1.0	22.6～27.5 (2.3～2.8)	Applied	4.4.4
Flywheel set bolt		M10×1.25	80.4～86.4 (8.2～8.8)	Applied	4.3.4
Bearing cap set bolt		M10×1.25	75.5～81.5 (7.7-8.3)	Applied	4.4.4
Crankshaft pulley set bolt	FC250	M12×1.25	83.3～93.3 (8.5～9.5)	Applied	4.3.4
	S48C		113～123 (11.5～12.5)		
Fuel pump drive gear nut		M12×1.75	58.8～68.8 (6.0～7.0)	Applied	4.3.4
Fuel pump gear bolt		M8×1.0	32.3～36.3 (3.3～3.7)	Not applied	-
Fuel injection pipe sleeve nut		M12×1.25	29.4～34.4 (3.0～3.5)	Not applied	-
Fuel injection nozzle nut		M20×1.5	49.0～53.0 (5.0～5.4)	Not applied	-
Governor weight suport nut		M12×1.25	68.7～73.7 (7.0～7.5)	Applied	-
Glow plug		M10×1.25	14.7～19.6 (1.5～2.0)	Not applied	-

12.2 Tightening Torques for Standard Bolts and Nuts

Item	Nominal thread diameter × pitch mm	Tightening torque Nm(kgf-m)	Remarks
Hexagon bolt (7T) and nut	M6×1	9.8～11.8 (1.0～1.2)	Use 80% of the value at left when the tightening part is aluminum. Use 60% of the value at left for 4T bolts and lock nuts.
	M8×1.25	22.5～28.4 (2.3～2.9)	
	M10×1.5	44.1～54.1 (4.5～5.5)	
	M12×1.75	78.3～98.3 (8.0～10)	
PT plug	1/8	9.8 (1.0)	-
	1/4	19.6 (2.0)	
	3/8	29.4 (3.0)	
	1/2	58.8 (6.0)	
Pipe joint bolt	M8	12.7～16.7 (1.3～1.7)	-
	M12	24.5～34.4 (2.5～3.5)	
	M14	39.1～49.1 (4.0～5.0)	
	M16	48.9～58.9 (5.0～6.0)	

Note) Lube oil is not applied to threaded portion and seat surface.

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